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BATTERY TRANSFORMERS.

SINCE the futile attempt to carry out the lighting of Colchester by means of direct currents and secondary battery transformation the pioneers of this system have not been idle. The first failure was due, no doubt, to want of experience, and the absence of perfection in the various details that go to make up a complete method of distribution, and most engineers profiting by the lessons taught by this experiment somewhat modified their views on the subject, but the inventors still clung fondly to their old plans, and waited for a fitter opportunity to put them into practice.

When the electric light industry had recovered from the effects of rash speculation and prohibitive legislation, and encouraged by success abroad, was again tempted to solve the problem of the economical distribution of electricity, a new competitor had entered the field, the alternate current transformer; a spirited contest took place between the two systems, and was fought out by the leading advocates of both sides in the arena of the Institution. The result at the time was a drawn battle, and it was left to practical experience to determine the survival of the fittest, and to evolve a complete system of distribution which should be commercially successful. At the time that the various schemes for the supply of the metropolis were brought forward, the Board of Trade adopted this view, and parcelled out the districts between the different competitors, seeking, where possible, to place the alternate and direct current systems in opposition, by giving them concurrent rights over the same areas, so that the general public might at least have a double chance of a satisfactory solution of the question.

Six principal companies shortly entered the field, each typical of its kind, viz., the London, with a double transformation from 10,000 volts; the House-to-House transforming from 2,400 volts, and the Metropolitan transforming from 1,000 volts. These three were on the alternate current system. The direct current system was represented by the Chelsea Company transforming from about 1,500 volts by means of secondary batteries and storing the whole amount; the Kensington and Knightsbridge running on the three-wire system and storing one-fifth of its output; and the St. James's and Pall Mall working direct on a three-wire system without storage. Later on the Westminster Company commenced work on the same lines as the Kensington and Knightsbridge.

In Major-General Webber's recent paper read before the members of the Institution of Electrical Engineers, he refers back to his contribution to the B.A. at Newcastle in 1889, since which date the Chelsea station, according to the author, has got to work, and proves a perfect success in every way. The automatic apparatus is afterwards described, in which many who once expressed disbelief are convinced of its utility. The opinions of other equally experienced men, however, of such automatic work is, that it is unwise to have anything to do with it.

E.M.F. governors with fine shunt coils, having important action dependent upon them, are unadvisable; they are too liable to be broken by accident. The automatic arrangement may be a most beautiful piece of mechanism, but it is not engineer's work, and it is certainly not a desirable thing for public lighting. Any hitch in the working would be attended with grave disaster.

Charging accumulators in series has been generally fatal to the batteries. In charging three stations in series, all the batteries are equally charged; but unless the districts get an equal discharge, they get out of order, and it requires very careful superintending on the part of the engineer to keep them in condition. There might be a very heavy discharge in one district, and a very slight one in the others, and to make them equal, the engineer has to pump out the other batteries; that was the one serious defect at Vienna, and there is very little difference between Chelsea and Vienna, almost the same number of batteries being employed. Charging at the latter place was performed in series, and discharge taken off in parallel, but fortunately most of the current was sent direct into the lamps. The great difficulty

as mentioned before, is to discharge equally. On the three-wire system, with batteries as employed by Crompton, the two sides of the system are perfectly independent, and the charge and discharge can be regulated with the greatest nicety.

The next point was the continuous current transformers. There is not the slightest doubt that sooner or later such apparatus will come very greatly into use; they are splendid things in their way, and they might yield an efficiency of 82 per cent.

In the transformer described, primary and secondary wires are wound on the same core, and the gallant Major-General goes on to point out that this is a very useful thing, because each primary wire, as it were, drives a secondary wire, and the strains are evenly distributed; there are many reasons against using a machine this way, for only absolute safety is acquired by earthing the iron of the transformers between the windings, so unless these are divided main fuses would not be much protection, and other devices would be practically useless.

In running direct current transformers, it is especially important if the primary breaks down that it should not be able to reach the secondary winding; it might then be objected that a stouter machine would be too costly, but it would pay any company to put in a heavy type of machine, for it is supposed that a company will last a good many years; therefore a machine, built to stand, would be far preferable in the long run, at the same time giving absolute safety.

Major-General Webber in his paper apologised for the breakdown of the Chelsea system by saying that his company, in common with the other companies, had to make the best of the difficulties in obtaining delivery of material. Considering that the E.P.S. Company is so deeply interested in the Chelsea Station, it would seem natural that they would be anxious to push on the work. The remarkable efficiency obtained with this plant is evidently that of a very careful trial run carried out with a cold condenser and a fully loaded engine, and not carried too far.

A most efficient station will be one like the St. James's with small sub-divisions of plant running at about three-quarter load. They have no losses from transforming, get most efficient dynamos made of the latest type by Siemens, there is practically no loss on the mains, the current goes straight into the lamps by meter, and the coal bill is reduced to 7·7 lbs. per Board of Trade unit sold. Crompton's station is about ½lb. higher than this; a fifth of his plant being in the shape of batteries, and with 75 per cent. return will make a distribution efficiency 5 per cent. lower than St. James's. According to Major-General Webber himself, they lose 30 per cent., Crompton losing 8 per cent. and St. James's 3 per cent.; yet the former claims a smaller coal bill. Major-General Webber endeavoured to meet Mr. Crompton's arguments by saying that abnormal conditions in the Chelsea Company are high. This company is the oldest, and having still abnormal conditions the outlook is not very promising.

The whole question turns on one point, and if Major-General Webber wanted to put himself right with his audience he should have published units supplied and tons of coal consumed. He allows a battery three years' life, which is rather giving himself away, for the general conclusion is that under *normal* circumstances the life of a battery is three years. It would seem then that the batteries have only another year to live.

Mr. Crompton in the discussion said if the figures given in the paper were doubled they would be nearer the mark. Nothing were more misleading than the figures of a trial test.

COST OF ELECTRIC TRACTION.

TABLE No. 5, published by Mr. Kapp in his first Cantor lecture at the Society of Arts (see last week's REVIEW), appears to have caused much commotion in certain quarters, and the figures contained therein have been freely discussed during the last week in electrical circles. The data referred to in this table were given to Mr. Kapp by Mr. Frazer, who managed the Barking Road line in the early days of its existence, when everything was in the experimental stage. We have never received any authorised figures from the officials of the company running these electric cars, but we have heard on more than one occasion that the depreciation of the secondary batteries was very great, and that the contractors were losing money on the price, 4½d. per car mile, paid by the North Metropolitan Tramways Company. According to Mr. Kapp's showing, the traction expenses at Barking Road amount to about 8d. per car mile, and there is no doubt that the public at large will accept this as a correct statement, corresponding with latter-day practice. Mr. Kapp, however, is wrong in more points than one; he includes the wages of the driver, 1·432d. per car mile, and depreciation of engine-shed in this estimate; whereas the "horsing" estimates of any tramway never contain these items.

The running expenses at Barking Road, as given in the Cantor lecture, represent an annual duty of only 100,844 car miles, which is equivalent to the continual running of four cars at the usual horse-car rate. It is quite certain that with four cars only on a line the "horsing" would amount to a considerable sum, not that the horses eat more in a small stable than in a large one, but the superintendence of stables and administration forms a large percentage in such a miniature undertaking. It will be noticed that the wages at the Barking Road depôt are put down at £677. This would certainly not be trebled in the case of a dozen cars; in all probability it would not be doubled. The depreciation of batteries at Barking Road is put down at 2·818 pence per car mile; yet it is known that some contractors are willing to maintain tramcar batteries for one penny per car mile.

The depreciation of motors and gearing in table No. 5 seems out of all proportion with the experience of other electric tramways, and surely the accumulators cannot be blamed for defective engineering work. But even if we were to leave these items as they stand, and only deduct drivers' wages, and the excess for accumulator depreciation, the cost of traction in this case will not exceed 4·8 pence per car mile, with four cars on the road. Mr. Kapp tendered a kind of an apology on Monday last when opening his second lecture, practically withdrawing the statements he gave in table No. 5; it was evident that he could not substantiate

the pessimistic views set forth a week ago, and which have been published in technical journals, some of them having taken Mr. Frazer's figures as gospel, and tried to prove that accumulator traction is hopeless, whereas the advocates of this system assert that they are nearer than ever to a complete solution of this interesting, though difficult, problem.

CONSULTING ELECTRICAL ENGINEERS.

AN esteemed contemporary whose utterances, however severe they may be, are, we feel sure, never characterised by anything but the editor's earnest desire for honest and straightforward business relations between the various branches of the electrical profession, has recently made itself somewhat conspicuous by two articles reflecting upon the consulting engineer. On the first of these we do not intend to comment, beyond saying that there is much truth in the writer's contention, but in the second he has, to our mind, completely overshot the mark, and we will in consequence endeavour to show on what points he is mistaken. We do not attempt this for the purpose of shielding the faults of consulting electrical engineers considered as a body, or even to palliate any errors of judgment of which certain individuals may have been guilty, for it is not the policy of the REVIEW to spare the rod where we consider a mild chastisement will act beneficially. But when an article is ostensibly based upon documents in the writer's possession, he ought, at all events, to be sure of his line of argument, or his readers are prone to believe that another mind than his own had inspired the thoughts which his pen committed to paper, and that a usually keen perception of right and wrong had temporarily become obscured. This seems to us to have been actually the case with regard to the leader which our contemporary last week devoted to the electric lighting of Dublin, and if anybody cares to wade through the reports, correspondence, specifications, estimates, &c., which were published in conjunction with the article, he cannot fail to become convinced that the subject matter has neither been read, learned, nor inwardly digested in that calm and deliberate manner which is so necessary to enable one to arrive at a fair and impartial judgment upon the merits of the case: in other words, that the tirade was the result of inspiration.

The contention is that a consulting engineer should draw up plans and specifications to guide contractors, and not merely issue a few guiding clauses, leaving the contractors to make their own plans, their own drawings, and their own specifications. The contractors are not on the same footing, and in the result the brains of able engineers are sucked, to their great detriment, by men who are incapable of initiating comprehensive and complete schemes, and in all this we agree.

Furthermore, it is insinuated that both the Consulting Engineer to the Corporation and the Borough Engineer of the City of Dublin have betrayed the confidence reposed in them by selecting a scheme, picking and choosing parts of indicated ideas, and accepting some one or other contractor to carry out the work, not as proposed by that contractor, but according to his plans with improvements suggested by other competitors. The taking of a notion from a non-successful competitor in this fashion, says our contemporary, is a flagrant breach of confidence, and the sooner a systematic attempt is made by contractors to condemn it, the sooner will they be relieved from the intolerable burdens which now encumber them in sending in tenders.

"The worst mistake made in the case was in suggesting the adoption of part of Mr. Gordon's scheme, and giving the work to another contractor. Messrs. J. E. H. Gordon and Co. sent in a complete scheme with elaborate drawings—a scheme which it is allowed would, if carried out, save from £800 to £1,200 a year in working. Of the system—suggested, be it recollected, only by these contractors—the engineers report: 'We are of opinion you will do wisely in arranging to adopt this system. It will involve an extra expenditure on the basis of the lower tender of about £3,000; but, as pointed out by Messrs. Gordon & Co., the economy will be equal to nearly 25 per cent. of electricity sold.' Again, the engineers say: 'Sub-transformer stations, as recommended by some of the contractors and endorsed by us.' If our information is correct, and, according to the documents before us, we cannot detect anything wrong in the conclusion, no other contractor than Messrs. Gordon tendered on the sub-station plan."

In the expression, "if our information is correct," lies the pith of the whole matter, and our contemporary, relying on its correct appreciation of the documents in its possession, comes to the conclusion that only Messrs. Gordon tendered for sub-stations, and with this point we will first of all deal. Now, in the published reports given on page 197, we read the following:—"Referring to the proposition made by *several contractors* as to the grouping of the transformers in five or six sub-stations, instead of having separate transformers in the houses of each consumer, we are of opinion that you will do wisely in arranging to adopt this system." Now, how on earth can we reconcile this statement with the assertion of our contemporary that Messrs. Gordon's firm was the only one to tender on the plan of transformer sub-stations, that is, unless a hard and fast line be drawn between tenders and suggested plans for the same thing without giving the cost? Is there not a well-known company, with works a little way out of town, whose London centres are, in reality, nothing but sub-stations, and is not this arrangement common to everybody who chooses to adopt it? If Messrs. Gordon had been the only people to suggest this method of operation, there might have been some ground for complaint that the companies who were successful in obtaining the contracts should have been, as an after-thought, invited to add to their tenders the additional expense incurred by sub-stations; but as this system is not confined to anyone in particular, there seems to have been no objection to asking those who omitted to mention sub-stations in their estimates, to include them. It is on this point that a "gentleman" is reported to have commented in the following language:—

"You will see in this letter that the House-to-House Company are asked to give tenders for a sub-station system at a few hours' notice. Now I assert that this is proof positive they were asked to copy Mr. Gordon's plans, for our engineers must have very well known that though it might have been possible to copy plans in a few hours, it would have been ridiculous to have asked any company to independently design that system in that time. I find that to work out the system in Mr. Gordon's office occupied the whole time of three skilled men for six weeks, and Mr. Gordon informed me that quite recently, having to design this system for

another town, it took 16 days, even though the staff had the whole of the Dublin plan and calculations before them ; this only refers to the details of the sub-station system, and not to the whole system."

Now, whatever the Gordon plan may have been, and it seems nothing short of the ridiculous that six weeks should have been involved in completing the details of a few sub-station connections, even if the office boy had been the only individual engaged in the task, it will be evident by what follows in the letter of the Borough Engineer that this precious plan was not infringed :—

Engineers' Office, City Hall, Dublin, December, 1890.

Dear Sir,—Please let me have, by 12 o'clock to-morrow (Tuesday) at latest, the extra amount to be added to your tender for sub-station transformer system (if used).

There must be one line of cast iron pipes for the H.T. primary wires, two lines of cast iron pipes for three-wire distribution, and two lines of cast or wrought iron pipes for arc light wires. There should be seven sub-stations, each with 10·4 H.P. electrical transformers, and each with a switchboard, enabling each pair of transformers to be connected as to the primary mains, and a three-way double-pole switch to each pair of transformers, the pair of transformers to be connected on to two or three wires of the distribution system.

This addition to tender must include extra cost of cables, which must be to original specification as regards loss of energy. Please also state diameter of pipes.—Yours faithfully,

W. G. Bingham, Esq., (Signed) SPENCER HARTY.
House-to-House Electricity Co., Dublin.

No plans are here required, no drawings of any kind ; the Borough Engineer simply asks for the amount of extra money which the fitting of seven sub-stations will entail, so that our contemporary's wonder at revised tenders, revised drawings, revised plans, &c., by "12 o'clock to-morrow," being accomplished, is quite beside the mark.

The map of the streets to be lighted, and the lengths and diameters of wires being already known, surely it would not necessitate more than a few hours' labour on the part of anyone used to estimating to comply with Mr. Spencer Harty's request, and we have yet to learn that he committed a breach of confidence to other competitors by his action. Our contemporary evidently bases its contention on the supposition that only Messrs. Gordon suggested sub-stations, but it is clearly shown that other would-be contractors did the same thing, and that the Dublin engineers did not therefore, when recommending this method of arranging the lighting circuits, allude specifically to Messrs. Gordon's tender, which simply pointed out that a certain economy would result from its adoption, whereas the others were content to specify their use merely.

We also submit that the engineers to the Dublin Corporation have not failed in any respect with regard to preparing a proper specification. It is true that an architect himself prepares the plans and specifications for a house, and that a civil engineer makes the necessary provisions for a new line of railway, but in these instances, as in many others, everything is reduced by constant practice to mere routine. Such is not the case in electric lighting, where contractors have their special dynamos, methods of laying conductors, transformers, and the numerous other appliances which together make up a complete system ; still, in glancing through the Dublin specification, we find the following items clearly set forth in a manner which intending contractors would deem quite sufficient for their purposes.

Very complete details of the necessary engines, boilers, alternating current dynamos, regulating apparatus, transformers, meters, conductors, arc lamps for public lighting, and generating station ; the contractor in each case is only asked to furnish drawings showing his proposed arrangements, a request at which nobody need cavil. Plans and elevations of the central station are given, and a map of the streets, with positions of lamps, &c., and we do not hesitate to say that any reputable contractor would bear out our contention that the specification prepared by the responsible engineers is ample, in so far as anything can be called complete in electric lighting. We can scarcely conceive that our contemporary was in possession of this document, for had such been the case it could not have failed to see the error into which it fell.

Specifications and plans being obtainable, each contractor's tender was, or might have been, based upon the same conditions, and to our way of thinking the Dublin authorities have not, as has been stated, taken a leap in the dark. The insinuation that their advisers hoped to get amongst the plans sent in, something that suited them, is utterly uncalled for and unjustifiable, and we hope that it is not too late for our contemporary to retract a good many of its strictures, which are evidently based upon incomplete and totally unreliable information.

It is a pity, perhaps, that after inviting tenders for a certain purpose they should not have been strictly adhered to, or else fresh estimates requested from everybody when the sub-station modification was advised, but the worst that can be said of the conduct of either Mr. Spencer Harty or Mr. Manville is that an error of judgment was perpetrated. The probability is that in fairly and impartially trying to please all by bringing the estimates into the same category they signally failed, except in the instance of the companies who secured the contracts.

It would seem that the lesson to be learned from Cambridge, Dublin, and, indeed, several other cities, is that the consulting engineer must be more wary. He believes that when he is advising the committee appointed by any corporation which seeks his advice, he is free to express himself candidly on the whole question at issue, and being under the impression that the enquiry is held with closed doors, he imagines that his professional opinions and reports are private property, unless there are special reasons given, and permission obtained for publishing them. A corporation is a public body, contractors are public men, so it is useless to look to either as considering a professional report of a private and confidential nature. The consulting engineer must therefore, personally look after his own interests, but we fear that the episodes to which we have drawn attention will be the means of making him more chary of giving his honest convictions, lest he should be accused of harbouring a pet scheme, and favouring certain contractors or systems to the exclusion of all others.

A Great Novelty.

A CERTAIN "J. G." is apparently poking fun at a French contemporary devoted to general science, as with due gravity he describes in that journal a method (fully illustrated) of determining the position of a total disconnection fault in a telegraph wire (either aerial, underground, or submarine). The method consists in measuring the capacity of the broken length by comparing the discharge from the line with the discharge from a condenser. No one, of course, has ever heard of the method before, and we only regret that our limited space prevents our reproducing such an original and ingenious idea.

ELECTRICITY, ETHER, AND MATTER.

By J. GRAY, B.Sc.

(*Concluded from page* 210.)

THE theory that the stream of electrical energy flows from the voltaic cell, the dynamo, or other source, to the place where the energy is used or transformed, along the equipotential surfaces in the strained dielectric, rests on the assumption that this dielectric medium possesses the property of *transverse rigidity*. It is by virtue of this property that bodies resist change of form; it is peculiar to elastic solids, but not to gases. For example, when a load is placed on the end of a cantilever, it is bent down to a certain extent till its transverse rigidity, or tendency to assume its original form, just balances and supports the load; or when the prongs of a tuning fork are pressed together, by virtue of this rigidity they will fly outwards when released.

The state of the dielectric surrounding a voltaic cell in circuit, according to Poynting's theory, may be very conveniently illustrated by means of a tuning fork; certain modifications, of course, being necessary to suit the different circumstances. The slice of the elastic dilectric (fig. 3) contained between the equipotential surfaces 2 and 3 on the right side of the battery, terminating at the conductor, corresponds to one prong of the tuning fork; the slice contained between the corresponding surfaces 2 and 3 on the left, and

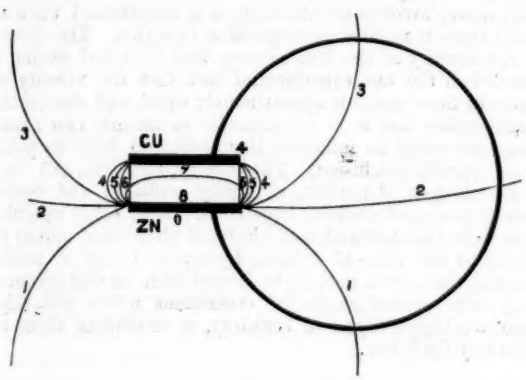


FIG. 3.

also terminating at the conductor, corresponds to the other prong of the tuning fork. If the analogy be strictly carried out, one prong would be longer than the other, and would be bent round till the ends of the two prongs stood facing each other; but for simplicity it may be supposed that the prongs are of the same length and terminate at the conductor, which may be represented as a frictional surface in contact with the ends of the prongs. If a series of impacts be suitably applied to at the junction of the two prongs, transverse waves will proceed outwards to the ends, where the energy of the vibrations will be transformed into heat by rubbing against the frictional surface. In an exactly analogous way, a series of impacts or disturbances applied to the dielectric tuning fork, in fig. 3, by the chemical combination at the zinc-acid surface, flows outwards in a series of transverse waves to the ends of the dielectric prongs in contact with the conductor, where the energy is transformed into heat by some action not yet fully understood.

The property of transverse rigidity in a body implies a certain attraction or cohesion between its ultimate particles. When a load is placed on the end of a cantilever at any cross section of the beam there is a force tending to make the two parts slide on each other. We have, in fact, what engineers call a shearing stress; and this tendency must evidently be resisted by some attraction between the particles of the beam. This force of cohesion in solids prevents the particles from moving freely relatively to one another; in a liquid or a gas, on the contrary, where there is little or none of this cohesion, the particles can move freely relatively to one another. Consequently, the latter offer little or no resistance to the passage of other bodies through them, while the former offer an immensely greater resistance.

The elastic solid theory of the luminiferous ether first propounded by Green, and still almost universally accepted, has this grand defect, that it fails to explain how solid bodies, such as the planets, can move through it without any measurable resistance. This is so completely opposed to all our experience of matter that one ought to be satisfied that any attempt to explain the phenomena of light and electricity by means of a liquid or gaseous medium is hopeless, before the elastic solid theory is looked upon as anything more than an illustration, chiefly for the use of mathematicians.

The hypothesis that the waves of light consist of transverse vibrations of the luminiferous ether is necessary to explain the phenomena of polarisation; and the Amperian theory of magnetism seems to point to the conclusion that transverse combined with longitudinal waves are flowing through the magnetic field. The elastic solid theory was invented to explain the existence of transverse waves.

Since the elastic solid theory appears to be condemned by the fact that solid bodies are known to move through the ether with no perceptible resistance, it becomes necessary to consider what path the energy will follow on the assumption

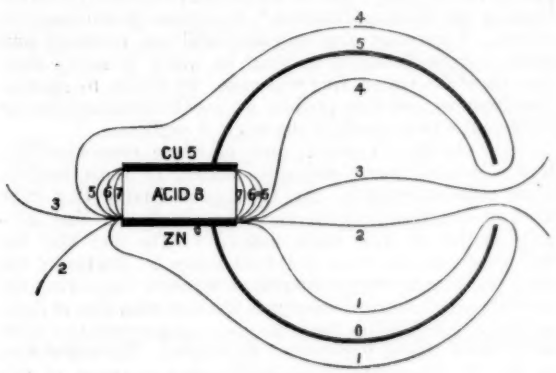


FIG. 2.

that the supposed common medium of light and electricity is a fluid. In fig. 2, the dielectric is represented as in a state of electrostatic strain before the circuit is closed. The field is mapped out by lines of equal pressure or potential, and if lines of force were drawn they would appear as curved lines cutting the equipotential lines at right angles. If the dielectric medium is a fluid without rigidity, the only way in which it can be strained is by compression or rarefaction. The electrical displacement takes place along the lines of force, the pressure at right angles to the lines of force being balanced by the equal pressure in the tubes surrounding it. When the strain is released along the line of the conductor by completing the circuit, a series of longitudinal waves will flow along the lines of force.

When a current is flowing in a conductor, it can be easily seen from fig. 3 that the lines of force immediately surrounding the conductor must run parallel to it, and therefore the conductor may be considered as encased in tubes of force. The conductor may be represented as a tube of which this casing forms the sides, filled with small particles to represent the molecules of the conductor. Longitudinal waves passing along the lines of force surrounding the conductor will thus impart a longitudinal motion to the encasing tube, and the energy of this motion will be transformed by some means at present unknown into heat vibration of the molecules of the conductor. The energy in tubes of force not in contact with the conductor cannot be dissipated in this way, and must therefore be discharged by the side pressure of these tubes, and thus flows at right angles to the lines of force in the form of waves of condensation and rarefaction till the con-

ductor is reached. From these considerations, it would appear that if the electric medium is a fluid the stream of energy flows from the source to the conductor partly along lines of force and partly along equipotential surfaces. It might be represented generally as divided into two streams, one of which flows along lines of force, and the other along equipotential surfaces. These two streams cross each other everywhere at right angles, and as the combination of two longitudinal waves at right angles, when properly timed, produces circular motion of the particles over which they pass, it is conceivable that this arrangement may fully account for the Ampèrian rotations supposed to be necessary to account for magnetic effects.

Consider a single tube of force starting from the acid side of the zinc plate of the battery, passing through the substance of the dielectric outside and terminating at the other side of the zinc plate. According to the hypothesis suggested above, when the current is flowing a stream of longitudinal waves, resembling sound waves, in air, starting from the zinc acid surface, flows along the tube of force. The whole of this wave energy, however, does not reach the other end of the tube; it is being drawn off at the sides along the whole length of the tube, towards the conductor, at such a rate that the whole of the energy in the tube has been discharged when the end of the tube is reached.

This hypothesis requires that the ultimate particles of the electric medium should be capable of deflecting a stream of wave energy at right angles to its original path. A medium whose particles are in a state of rapid rotation may possibly possess this property; and such a medium has already been devised by Sir William Thomson * to explain electro-magnetic effects. The vortex atom may also fulfil the necessary condition; an oscillation of the fluid in which it moves along the axis of the vortex ring will cause its radius to increase and diminish, and thus produce an oscillation everywhere at right angles to the path of the original oscillation.

Is the electrical medium, some of whose properties have been discussed above, ordinary matter, or some medium of a different order? Mr. Sprague maintains that "the facts of electricity require no ether at all, and that ordinary matter is their whole source." † The fact that the velocity of electric waves and light waves is practically the same has already been adduced as strongly supporting the view that the electrical medium is identical with that of light, so that it would follow from the above proposition that light waves must also be transmitted by matter. The calculation of Sir W. Thomson given at the commencement of this article shows that the necessary quantity of matter could not be derived from the earth's atmosphere, so that if matter is indispensable it must be derived from some other source; perhaps from the sun's atmosphere.

There are many other considerations, however, which seem to point to the conclusion that light is not transmitted by matter. For instance, one would expect that a Crookes's tube would become more and more opaque to light the higher the vacuum becomes; but this is not the case. Again, wave disturbances produced by impact in matter do not in any case known travel with a velocity anything like so great as that of light; and, though it may not be conclusive evidence, it appears to be impossible to get any intelligible explanation of electrical and chemical attractions without supposing some medium of a higher order of tenuity which by its differing pressures on opposite sides of an atom of matter will produce attractions and repulsions.

The existence of varying pressures in fluid ether, is, however, opposed to our experience of material fluids; but this may possibly be explicable by the selective action of a fluid of a third order, bearing the same relation to the other that the ether does to matter. If such a third fluid exists, many considerations point to the view that it corresponds to what we call electricity. If the atom of ether, by reason of an inherent rotation has the power of propelling the electric fluid in a definite direction, just as a centrifugal pump has the power of propelling a fluid in which it is immersed; such an action would oppose any current which might be produced in the fluid in the opposite direction. This may account for the resistance of a dielectric to the passage of electricity through it. The vortex atom theory of the ether furnishes us with an atom possessing the power of propelling the fluid in which it moves in a definite direction; and thus a medium composed of vortex atoms may possibly be capable of sustaining the same varying pressures as exist in an elastic solid, without losing its fluidity. Such varying pressures have been proved, by Thomson and others, to be sufficient to account for electrical attractions and repulsions.

The above theory is in general agreement with the conclusions of Giese, Schuster and others that the atoms of matter carry charges of electricity, and that a current of electricity can only be maintained in a gas by a diffusion of the charged atoms through it.* The electrolysis of liquids has also been explained by the theory of atomic charges.

Mills's definition of a hypothesis is "a supposition made (without evidence or with insufficient evidence of its own) in order to deduce conclusions in agreement with real facts, the agreement being the proof of the hypothesis." That the proof of a hypothesis should amount to certainty, it is necessary that the hypothesis should account for all the facts, and also that we should have before us all the possible or admissible agents. Examined by this test very few, if any, hypotheses can be looked upon as certainties. Newton's theory of universal gravitation, and Dalton's atomic theory may be looked upon as two of the most firmly established hypotheses; yet in the case of the latter, at least, there appears to be some recent experimental results for which it does not fully account. The undulatory theory of light gives the only satisfactory explanation as yet of the phenomena of polarization and interference; but when considered as founded on the elastic solid theory of the ether, the agreement of the conclusions with fact is far from complete. The difficulty of explaining the unresisted motion of matter through an elastic solid has already been mentioned; and, moreover, the elastic solid theory involves the existence of a longitudinal wave to which there is nothing corresponding in optics. The theory of the identity of the luminiferous and electrical media is founded on the one experimental fact that the velocity of waves in these media is approximately equal, and also on the consideration that it is unreasonable to assume two media where one would be sufficient, there being no facts to point to an opposite conclusion. This theory, therefore, can only be looked upon, at present, as highly probable, and consequently as a good working hypothesis. Most other speculations as to the explanation of electrical phenomena appear to belong to the class of working hypotheses; but it would evidently be a great mistake to discard them on that account. They form rational guides for experiment which will raise them to a higher degree of certainty, or annihilate them to make way for better.

* "Jour. Inst. Elec. Eng.," Vol. xviii., p. 29.
† "Eng. Mech.," Vol. lii., p. 210.

* Wiedemann's Ann., Vol. xvii., p. 537, and Proc. Roy. Soc., Vol. xlvii., p. 526.

THE PROLONGATION OF THE GAS AGREEMENT AT BUDAPEST.

[FROM OUR OWN CORRESPONDENT.]

THE negociations between the city of Budapest and the local gas company, which have already lasted for more than a year, have at last reached a stage which seems to justify the hope that no further agreement difficulties will stand in the way of the introduction of the electric light, and that in consequence the aspirations of the public will soon be gratified by the opportunity of obtaining the electric light from a general central station. The gas company has acceded to the last demands of the city, with the exception of two points, which in fact contained stipulations too onerous. It is now only requisite that the city declares itself satisfied with the valuable concessions obtained, which in the position of affairs may be justly expected, for the present monopoly of the gas company—severely hurtful to the interests of the inhabitants—will make way for rational means of lighting, and the

municipality of the capital will at last obtain the right to grant concessions for the erection of electrical works, applications for which have been submitted some time ago. This right of the city is so valuable that the present proposals of the gas company, will, without doubt be accepted.

These proposals, which are based upon the condition that the gas agreement is prolonged for fifteen years—to 1910—with renunciation of the present monopoly, as against other kinds of lighting, runs as follows :—

1. As soon as the new agreement is definitely accepted, we (the gas company) renounce the privilege stipulated in the present agreement, which is secured to us as regards the electric light, or any other kind of illumination, on the counter condition that, as regards the electrical or any other light, no one shall receive an exclusive right or any privilege, and that every one (consequently, ourselves also) may compete for such an undertaking on an equal footing.

2. In accordance with the wish of the General Council, we reduce the present price of gas to private consumers, beginning from the first day of the month following the date of the formal acceptance of the new agreement, by a half kreutzer yearly, per cubic metre, until the price of gas for lighting becomes 10 kreutzers, and that for industrial uses reaches 8 kreutzers per cubic metre.

(This latter reduction of price has not been demanded of us during the recent negociations but we take the present opportunity of making known our views.)

3. Concerning the first part of the third point we express ourselves below.

The second part which demands that gas to be consumed in the municipal buildings or in premises hired for official purposes shall be supplied during the whole duration of the agreement shall be supplied at 7·42 kreutzers, we are willing to accept.

4. We agree that we, from December 16th, 1895, to December 15th, 1910, *i.e.*, for the entire duration of the new agreement, shall furnish gratis the quantity of gas needed for the supply of the public street lamps in the same proportion to the private lighting as it has been furnished in the year 1889.

But if the municipality wishes that this amount of gas to be supplied gratis for street lighting should be expressed in the same percentage proportion to that consumed privately as in the year 1889, we accept this modification ; but in this case the quantity of gas supplied in 1889 for street lighting cannot be taken as a minimum, but the same percentage must be maintained whether the private consumption rises or falls, for we cannot undertake the risk of bad years if the possibility of compensation by good years is withdrawn.

We must stand by the remark made to the commission that gas can be supplied gratis in those streets only where mains have already been laid for street lighting, or where they have to be laid by us according to Section 6*a* of the present agreement.

5. With respect to this same point we make a further remark below.

6. We are prepared to organise here in Budapest such a local board of management as—with reference to the fact that the seat of the company is in Austria—shall correspond to the arrangements of Hungarian commercial law and which is provided with the full power necessary for settling all questions which may arise out of the present agreement or that which is proposed.

We accept, therefore, the conditions of the General Council, 1, 2, 4 and 6 as well as the wish expressed in the second part of 3, but regret that we cannot possibly accept the wishes or proposals laid down in the first part of section 3 and in section 5.

Section 3 demands that we should supply during the continuance of the present agreement from the first day of the month following the conclusion of the agreement to December 15th, 1895, half the quantity of the gas used in 1889 for street lighting, and that from December 16th, 1895, *i.e.*, from the beginning of the gratis lighting we should bear half the cost of maintaining and attending to the lamps.

In our statements drawn up for the purpose of the negociations, we have shown that in consequence of the reduction of the price of gas to private consumers and of the gratuitous character of the street lighting, we give up more than 3½ million florins.

By accepting the wishes of the General Council we renounce our exclusive claims as against the electric light, &c., and have to compete with such illuminants. By giving up 3½ million florins we have come to a limit which we cannot pass without imperilling the very existence of our undertaking. Now, half the amount of the gratis street lighting for the remainder of the present agreement would at the lowest estimate reach 600,000 florins, and half the maintenance of the lamps from December 16th, 1895, during the 15 years of the new arrangement would also amount to nearly 600,000 florins."

After further explaining the financial reasons why they are unable to concede the points, sections 3, 1 and 5 the Gas Company go on to say :—

"The danger for us is not as many suppose, lest the gas works should be bought up at the valuation determined in our agreement, as in this case we should get back the capital which we have invested, but the very opposite. The city is *not bound* to buy up the gasworks after expiry of the 15 years' agreement, and in all probability, in consequence of the inventions and improvements which will be made in the meantime, it will not purchase our obsolete gasworks, which must occasion us a serious loss. This is an imminent and probable danger against which we have no means of protection."

How strongly the want of the electric light is felt in Budapest appears best from the fact that—as we learn—recently there took place meetings of representatives of the city in the different wards in order to consider what position the representatives should adopt towards the authorities in case the proposals of the gas company are not at once accepted and thus the erection of the electric works should be again postponed. It has become known that the authorities intend to submit the affair for examination to a commission, whilst the representatives present at the meetings are of opinion that the question has reached maturity, in consequence of the proposals handed in by the gas company, and that hence every delay in coming to a decision means, in effect, an injury to the public. The meetings resolved not to assent to any proposed adjournment but to press for an immediate decision, and as no further concession can be expected from the gas company, to vote for the immediate acceptance of their offer.

MAJORITY OF THE TELEGRAPH SERVICE—A RETROSPECT.

(*Concluded from page* 205.)

A SUBJECT which has hitherto been regarded with not a little soreness by practical telegraph officials, who, however, cannot be held responsible for the matter, is the depletion from time to time of the established staff, through superior inducements held out to experienced men by both old and new cable companies. Great numbers of clerks of vast and varied experience and of the highest operative skill have since 1870 cast in their lot with these more or less private enterprises, and in many cases have found the change one not to be regretted. In 1874 the Direct United States Company secured a splendid selection of experienced clerks, both operative and technical, chiefly for their North American offices. Later on, the French Atlantic Company and the Commercial Company, amongst others we could mention, made further inroads on the home trained staff.

When it is considered that the Government trains its own telegraph clerks right from the beginning, maintaining large schools of telegraphy in the leading commercial centres throughout the United Kingdom, it may be said that these schools are the training grounds from which the great cable companies ultimately recruit their staff. It requires little stretching of our imagination to understand the regret with which telegraphic superintendents and others concerned witness the secession from the Government service of men regarded as the backbone or mainstay of the particular office to which they have been attached. The late Mr. Patey, Assistant Secretary to the Post Office, in course of examination by a Commission some years ago, stated plainly that a thoroughly efficient clerk was not to be expected until after five or six years' service. He has never been considered as a

personage in any way partial to the claims which telegraph clerks and the service generally set forth during his career at St. Martin's-le-Grand, but his testimony served to show that the directors and managers of cable companies were keenly alive to the benefit to be reaped by securing experienced, full-fledged, and State-trained operators.

Indifferent treatment, neglect, official tyranny, and wretched pay, therefore have placed many of the best of the "old timers" in responsible, yet lucrative positions, in services outside the sphere of Post Office red tape and departmental despotism.

The methods of maintaining discipline in the old companies varied greatly, and speaking generally were of a more or less elastic nature; a common way of dealing with the almost unavoidable occurrence of trivial errors, oversights, omissions and nameless little irregularities was to send the unfortunate delinquent before the "manager" or "secretary," and awe him into a state of real or feigned repentance by more or less powerful oracular admonition. Cases of a more serious nature would be punished by the infliction of fines varying in amount according to the nature of the offence or irregularity committed.

Under the new administration a system of discipline was set up by which everything throughout the telegraph service was controlled by foolscap and red tape. The most absurd and trifling matters in the hands of those invested with a "little brief authority" became affairs of the most serious import. Much writing, signing, counter-signing and noting of orders became one of the fashionable foibles of those anxious apparently to introduce a system which reduced everything to a system of question and answer. Anything done by the staff in the slightest degree out of harmony with the frequently peculiar ideas of the users of foolscap and red tape was summarily dealt with as "insubordination." For instance, it was no uncommon thing for clerks working heavily pressed wires to find that their anxious zeal had been the means of securing to them, at the end of the week, four, five, and even six hours extra duty without pay—any appeal being regarded at once as insubordinate conduct and punished accordingly.

Doubtless the control of large bodies of men must be maintained on certain fixed and general principles, but there is no reason why forbearance and equity should not be observed in dealing with intelligent masses in the more trying and exacting arena of commercial routine.

It is quite possible that the system of control by foolscap gave many opportunities to persons of vindictive and malicious natures for the perpetration of personal and tyrannical irregularities which were cloaked under the authority of officialism. At all events, after enduring a protracted course of rigid discipline which, amongst other things, dealt very harshly with the most inconsequential operative faults, a period of partial relaxation was experienced, to the undisguised delight of all ranks in the service, for even the martinets were weary of the abnormal use of pens and paper. No doubt some light had broken in at the eleventh hour on the severe disciplinary autocrats of the Telegraph Department. To whatever the change was due we know not, but it is certain that for the last ten years or so a measure of discretion has been exercised in inflicting punishment on telegraph clerks for trifling business errors. It is no longer the rule to deal indiscriminately with the staff; more consideration is observed, and in this respect the clerk is, in a measure, encouraged to do his best for the public and the service, for former repressive measures were calculated to retard rather than facilitate and improve the flow of business, and there can be no doubt that in this matter the present is the more satisfactory condition of affairs.

After much discussion, and not a little apprehension and perplexity on the part of Treasury Lords and postal officials, October, 1885, witnessed the introduction of the reduced telegraph rates throughout the United Kingdom. It cannot be denied that the result was a great cheapening of the cost of telegrams, especially to those using the wires to the extent that is common amongst stock, ship, cotton, and metal brokers, and, indeed, most branches of productive industry. At the same time, it resulted in a practical consolidation of the labours of the telegraph army of operators, inasmuch as every word now telegraphed in commercial messages represents a coin—albeit, a humble one—known as a halfpenny. It was not an uncommon thing in the days when addresses were free to find them containing from 40 to 70 words, sometimes of not the slightest use to either the sender or receiver of the telegram, but occasionally of an indirect significance to the addressee, so that it was possible for a person in using 20 text words for 1s., to preface a pair of addresses of abnormal length, which were sometimes of great advantage to the parties concerned. Specimens of this sort of telegraphic evasion were quoted on one or two occasions in the House of Commons for the purpose of pointing the moral and adorning the tale, which ultimately led up to the so-called "sixpenny rate."

In nearly all cities and towns of any standing in this kingdom, the spread of telegraphic communication has led, quite as much as the spread of postal work, to the erection and re-building of post and telegraph offices on elaborate and extensive scales. No longer, as was to be seen in and about 1870, is the telegraph office poked up into a corner, an outhouse, or a closet; many "old stagers," as Edison terms the veterans of the wire and key, remember still how they were regarded as being more or less social nuisances which had to receive bare toleration. In the rural districts they were considered a mysterious brood, and were eyed occasionally as though it were possible that a cloven foot or a satanic tail might possibly be put suddenly in evidence. We remember one worthy tiller of the soil, a midland farmer, whose grandson, a telegraph clerk, was introduced to a party of homely provincials as a "worker of the telegraph." He was ever after regarded as a sort of telegraphic Wizard of the North, and treated with corresponding caution. With the more recent progress of affairs in the telegraph service we have dealt at length from time to time in these columns, and we need not re-introduce the subject here.

Telegraph improvements during the last 21 years have held on apace, and nothing proves this in a more striking way than to mention that the speed of an Irish news wire in 1870, under Wheatstone's system, varied from 40 to 60 words per minute. In 1891 350 is fixed as the standard speed. The same applies to long land-lines; the speed of a Scotch news wire now being kept at 400 words per minute, a wondrous advance on the 70 or 90 of 1870. Four clerks with stick "perforators," each perforating three slips, fed the three or four news wire "transmitters" at Telegraph Street in 1870.

In 1891 it is no uncommon thing at the Central Telegraph Office to see 70 men engaged in the operation of perforating or "punching" alone, each perforating machine working on a pneumatic method, and producing from four to eight identical slips for use in the vast system of news or press telegraphy, which has been one of the most striking features of the growth of the Department.

In closing this short general retrospect of the last twenty-one years of inland telegraphy, we have only to remark that whilst speed with accuracy can be developed on the present systems in the way we have witnessed during the last few years, the revolution in telegraphy so frequently talked of by speculative theorists does not appear to be in any immediate likelihood of fulfilment.

KENNEDY'S ELECTRICAL DISTRIBUTION METHOD.

By RANKIN KENNEDY.

In further reference to this new method, an account of which was given on page 236 of your last issue, and which was commented upon in an article of same date, the objections raised against the practical applications of the method in that article have all been successfully met, they having been to some extent encountered in the experimental plant first worked.

It will lead to a clearer understanding of the method if we go over these objections *seriatim*, and show how they clear out of the way of the practical application of the system.

First. The objection that "although the pulsating E.M.Fs. when superposed may pulsate, as shown in diagram

fig. 1, giving only 14 per cent. of fluctuation, yet the current curves may differ very much from the E.M.F. curves, and the pulsations or fluctuation in the current may be far from the estimated 14 per cent."

Now, this objection is not based on either experiment or theory; for, granted that the current curves of the two alternating currents from which the pulsating currents are derived are approximately sine curves, then if two such pulsating currents are superposed in their effects, the resultant effect will not pulsate more than 14 per cent. in theory.

FIG. 1.

Practically, the pulsation possibly amounts to 20 per cent., or even 25 per cent., but even that amount of pulsation is not objectionable, as can be understood by considering the matter a little.

If the maxima of the curve rises to 100 volts and the minima falls to 75 volts with the two curves superposed, then accumulators may be charged quite successfully if the number in series is such that their counter electromotive force never exceeds 75 volts.

Then as to the loss said to be likely to arise from hysteresis; in using the two currents combined in motors, &c., the writer of the objections has fallen into a mistake.

In using the combined currents in motors, &c., the two magnetise in the same direction, and really hysteresis, instead of causing a loss, comes in to aid in steadying the magnetic effect of the combined currents.

Experiments prove that even a single pulsating current, derived from a single alternating current, and which pulsates 50 per cent., magnetises approximately steadily and with little loss from hysteresis or eddy currents. As an instance, take the Thomson-Houston self-exciting alternator, in which massive cast iron field magnets are excited by a pulsating current derived by rectifying a single alternating current. Every electrician can call to mind many machines excited by a rectified alternating current. Experiment proves that two pulsating currents combined, as in the new method under discussion, magnetise with much less pulsating effect than 14 per cent., even although the current resultant may pulsate, and we know it does pulsate more than 14 per cent. This result is due to the fact that iron does not demagnetise at the same rate as the fall in current; in fact, is due to hysteresis, so that lamination is of no advantage, and the objections raised on the ground that the pulsations would cause loss in magnets and motors, due to hysteresis, have no existence in fact; hysteresis being rather an advantage in the new method, and in practice the combined currents charge accumulators and work motors without any difficulties arising from the slight pulsations.

Query: If a magnet can be approximately steadily excited by a current pulsating 50 per cent., how much more steadily shall it be excited by a current pulsating, say, 20 per cent.? The answer to that question disposes of the hysteresis objection.

Now for the second objection. "Although the impressed E.M.Fs. may be in quadrature, it does not follow that the resultant P.Ds. at the dynamo terminals are so." There are two equal circuits in the armature of the generator in equal fields, and the E.M.Fs. are therefore equal, their frequency are equal, the currents at all times are equal, their only difference is a phase difference of one-quarter period; it therefore must follow that the P.Ds. at the terminals of the dynamo *are in quadrature*; they cannot possibly, on any theory whatever, be otherwise; one pair of leads cannot take more current than the other, unless in case of accidents, short circuits, or failure of insulation, to all of which every system is liable to the same degree as this one.

Third objection. "The currents supplied at a distant point would probably be far from being in quadrature." Why? what has distance to do with the phase difference of the current? In practice they are found to have the same difference of phase at any distance; the theory being that whatever retards or accelerates the one acts equally on the other current, both having, as it were, to go over the same distance to get to the distant point.

Fourth objection. "The weight efficiency would necessarily be much lower than if the currents were perfectly in quadrature; this will certainly tell against the method." No doubt it would: but the currents *are* perfectly in quadrature, as explained in answers to objections 2nd and 3rd, so that there is nothing to tell against the system on the score of want of the proper phase difference.

Fifth objection. "The use of rectifying commutators." There is no difficulty with these as constructed on sound mechanical and electrical principles; there is no sparking, and no more wear than in the collectors of ordinary alternators.

Sixth objection. "It does not appear that the system has any great superiority over a combined direct and alternating plant."

This system is claimed to be superior not only to that combination of systems, but to all other systems, on the one ground alone that from *one* generating plant it can supply *all* classes of electricity consumers over the widest areas of supply. It can perform in the way of electricity supply all that the direct and alternating combined or singly can do, with the advantages of both combined in one plant, *therefore that one plant has a much greater earning of profits capacity.* The superiority is not claimed for any theoretical, mechanical, electrical or magnetical appliances in the method, but for the method itself considered as a method for distributing electricity at a rate placing it within the reach of the many. In the belief that the only direction in which improvement could be made in methods of distribution with a view to reduce the present prohibitive prices put on electricity, lay in the use of a plant that could be run at a paying load 24 hours in the day every day in the year, this method was invented.

The supply of electricity for lighting is necessarily of a very fluctuating nature, so that where lighting is the chief supply the capacity of the plant on the direct or alternating system is always very much in excess of the average output.

If we sum up the number of watts delivered in a year, and compare them with the number the plant is capable of delivering, say, running 16 hours a day all the year round, we will find a very large difference between them.

This method is essentially a high-pressure primary, with sub-stations of accumulators—motor generators—and transformers, feeding low-pressure service mains, and is calculated to be kept running constantly by these various sub-stations, so that there shall be less difference between the capacity of the plant and the actual output.

That there is much room for improvement in this direction can easily be proved by the data to be obtained from existing supply plants; and when we consider the length of time in a year these plants are practically idle or running at loads too small to pay, one is not surprised at the high rate charged for electricity supply.

The method required the invention of new appliances to carry it into practice. These we can now describe in detail, so that the method may be fully understood.

THE STRIKING DISTANCE OF ALTERNATING ELECTROMOTIVE FORCES.*

By ROBERT SHAND.

PROF. ELIHU THOMSON, while engaged upon experiments involving the use of alternating currents having a pressure of several thousand volts, found it necessary to ascertain the spark lengths which the pressures he employed were capable of producing, and also the change of spark length produced by increase in the density of the air through which the discharge occurred.

It is well known that numerous and elaborate experimental enquiries have at different times been made, having for their object the determination of the ratio of spark length or striking distance of a discharge of electricity in air (and various other gases) to the electromotive force producing it, and the determination of the law governing the increase of striking distance with decrease in the density of the air.

* *Electrical World.*

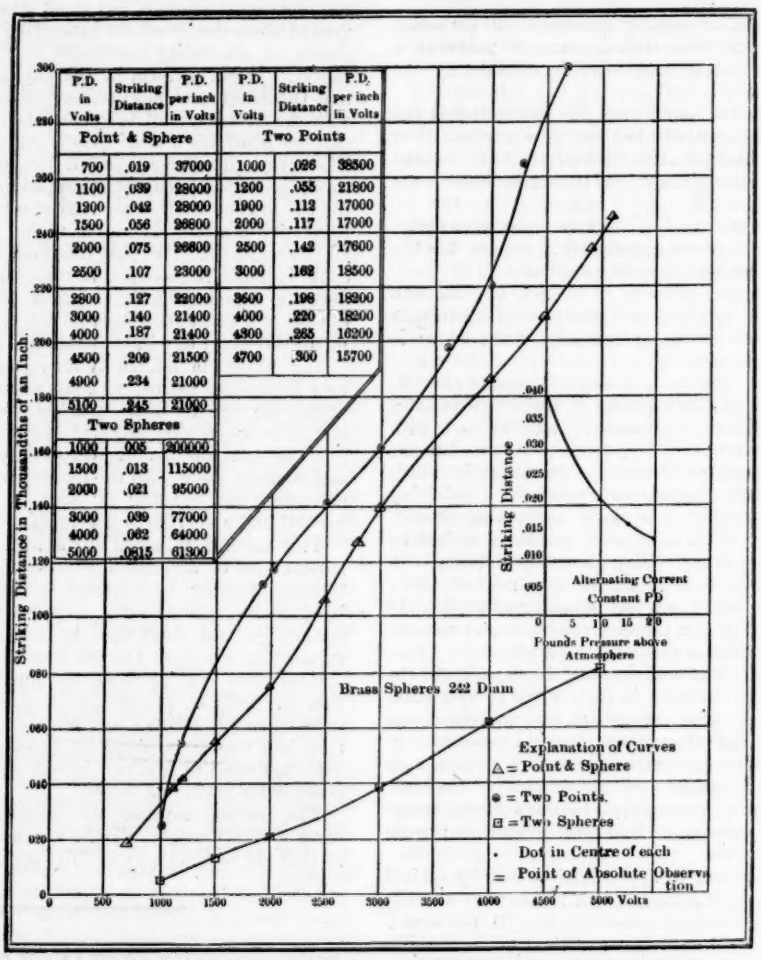
For the production of the high electromotive force required in the experiments, plate machines, Leyden jars, the Rhumkorff coil having a vibrator in the inducing circuit, and voltaic batteries, consisting of a very large number of elements, have been employed. The results obtained have been represented by formulæ, and arranged in tables which can undoubtedly be applied with certainty to cases the conditions of which correspond with those obtaining in the experiments, the results of which they represent.

None of these experiments, however, afforded data fitting the special cases occupying the attention of Prof. Thomson, who therefore, with the object of satisfactorily deciding the matter, caused to be made at his laboratory experiments, the results of which are graphically recorded on the accompanying diagram, which explains itself. The discharges took place inside a spherical glass vessel, five inches in diameter, and having three openings fitted with brass caps and leather collars. Through two of the openings, situated opposite each other, passed the discharge rods. The third opening could by means of a tap be opened to the outer air or connected with a pipe leading to a pressure pump. To indicate the distance separating the electrodes between which it was arranged the discharge should occur, one of the rods had a screw thread of one-fortieth inch pitch cut along that part of its length which worked through an opening in the glass sphere. It was also fitted with a graduated disc, which rendered small fractions of a revolution of the rod really observable. Wires from the secondary terminals of a small transformer were led to the discharge rods, the potential difference between which could be varied between the limits of 600 and 7,000 volts. The voltmeter used was one of Sir William Thomson's vertical scale electrostatic instruments, reading to 6,000 volts. An ordinary steam pressure gauge, having large scale divisions, was callibrated and used for the measurements of air pressures.

In making the experiments, the electrodes were brought toward each other until contact was indicated. The position of the discharge rod carrying the graduated disc was noted, and it was then withdrawn to a distance indicated by the number of revolutions of the rod.

The primary circuit through the transformer being closed, the pressure was increased until discharge occurred, the potential difference indicated by the voltmeter at the instant of such discharge being noted. In order to have the points of the voltmeter move steadily over its scale without vibration, it was found necessary to increase the pressure very slowly.

When observing the effect of increased air density on the spark length, the air pressure and electric pressure



CURVES OF STRIKING DISTANCE OF ALTERNATING E. M. F'S.

were maintained at a constant value and the electrodes moved nearer together until the discharge occurred; the spark length was then the remainder of the distance the electrodes would have had to move through before making contact.

The object in using pointed electrodes was to find the lowest potential difference capable of producing the spark; consequently the points were made as sharp and as perfect as the means at command rendered it possible to make them. It is obvious, nevertheless, that however great the care exercised, they must necessarily be more or less imperfect after each restoration. To this cause is undoubtedly due in large measure a somewhat irregular form of the curves showing spark lengths where a point or points were employed.

An inspection of the point and sphere curve shows a dis-

charge through ·019 of an inch of air produced by a potential difference of 700 volts. It serves to show the delightful uncertainty of points. This one was doubtless well made. When compared with point curves, the smooth, regular character of the sphere curve is noticeable, also the fact that the decrease of potential difference per unit length of air sparked through, with increase of potential difference and spark length, is more marked than in the case of points.

It will also be observed that when the spark occurs under pressures exceeding one atmosphere the slope of the curve grows less steep as the spark length is shortened by increase of air density. It would thus appear that the dielectric strength of air is not simply proportional to its density for pressures above two atmospheres. At pressures below two atmospheres, however, it would appear to be approximately so. A remarkable elongation of the spark was effected by heating the electrodes; the elongation was greater than the rarefaction of the stratum of air included between the heated electrodes would appear to explain.

The results of these experiments being required for application under practical working conditions, no special care was taken to dry or filter the air in which they were made.

PROCEEDINGS OF SOCIETIES.

The Institution of Electrical Engineers.

"TRANSFORMER DISTRIBUTION." By J. SWINBURNE, Member.

THE distribution of electrical power by means of alternating-current transformers can hardly be considered to have reached its final state, and though it may be somewhat difficult to say what system will be in general use ten years hence, there is little doubt that present practice will be largely superseded.

The method now in vogue is simple: it consists of running several independent dynamos, each with its own engine; each dynamo supplies a few high-pressure mains, which branch off, and supply transformers placed in the houses, or wherever light is required. This system, admirable for country towns or straggling villages, is hardly likely to be permanent anywhere else. It has many disadvantages. Except that all the dynamos and engines are in one building, it is nothing more than a collection of little independent installations. Each engine and dynamo supplies its own circuits, which are independent of all the others. In cases of a breakdown of an engine or dynamo, and in many cases of the leads, there is a stoppage till new arrangements can be made at the station. In addition to this, great lengths of high-pressure conductor are required, and this leaves openings for breaking down of insulation. The introduction of high pressures in private houses is dangerous if not well managed, and is in any case expensive, demanding compliance with all sorts of regulations, rendered necessary for the security of the public. The greatest drawback to the present system, however, lies in the waste of power in the transformers themselves. For a long time transformers were supposed to have an efficiency of about 98 per cent. More will be said on this subject presently.

It must be borne in mind that in spite of the drawbacks of the present system of putting transformers in houses, it may be, and probably has been, advisable for electric light companies to begin on that system, even in such places as London; but I do not think such an arrangement will pay in the long run, and a time will arrive when the mains will have to be changed and a low-pressure supply system substituted. When an electric light company begins, it has to take on houses here and there, where it can get them; but if its district is populous and wealthy, it should soon be enabled to work on some low-tension or sub-station system; and then the question is whether it is not better to lay the low-pressure mains at first, instead of beginning on one system and changing to another. Probably none of the existing companies mean to change from one system to another. There engineers have no doubt gone into the merits of the particular cases, and have come to their conclusions with great deliberation, and I do not think it well to offer any criticisms lightly.

PARALLEL RUNNING ACCORDING TO ORTHODOX HYPOTHESIS.

To begin at the beginning of my somewhat extensive subject, the first question is that of running machines in parallel. There are few matters of greater importance to engineers, and few on which opinions differ so widely. One says that machines will not run in parallel unless they have large self-induction; another that it is necessary to have iron in the armatures; another that they will only run together if they have no self-induction, or as little as possible. Others say that there is no difficulty in running them in parallel. No engineer who employs direct currents denies the advantages of running machines in parallel; if independent running is advisable in alternate systems, it is equally advantageous in the case of direct currents, and direct current stations should have separate circuits for each little district, each district being run by one dynamo. I do not think, therefore, independent running is advisable.

In 1884 Dr. Hopkinson showed that alternate current dynamos could be run in parallel, or could be run as dynamo and motor, and even that a machine giving a high pressure could be run as a motor off a circuit of lower pressure. In his paper he assumes that machines have "self-induction." He points out that the self-induction varies, but that it would be impossible to work out the calculations if the "self-induction" were taken as variable. For some reason or other, Dr. Hopkinson's calculations have received little application. That is to say, engineers have not taken actual cases and worked them out. Calculations have been made in which the various quantities have appeared in the form of letters, and diagrams have been drawn in which they are represented by lines whose lengths have been chosen at random, The geometrical treatment of many problems of this kind shows most of the actions very clearly to students, but is not always of valve in practical work, as in most cases some lines are so long and others so short that it would be difficult to avoid large errors. The result of this is that few of us, if any, have had a definite idea of how much "self-induction" a machine should have to make it work well in parallel with others. The general impression is that it is somewhat difficult to design a machine whose "self-induction" is large enough, and that most failures to run in parallel are due to deficiencies in this respect. I am using the term "self-induction" under protest, as I prefer to look at the question from another point of view. But whatever goes on in a dynamo, if the no load electromotive force is treated as constant, a value for a constant coefficient of self-induction can be assumed which would produce results somewhat similar to these found in practice. To overcome the difficulties arising from deficient self-induction in the armature circuit, Dr. Hopkinson has proposed to insert it artificially, in the form of choking coils, or to use induction couplers to compel synchronism. Without knowing that it had been done before, I described a similar arrangement to the Institution a few years ago.

In the spring of 1890 Mr. Mordey read a most important paper, in which he described some experiments on alternate machines. He argued from them that self-induction was deleterious, and that machines would run together best if they had none. In the discussion, Dr. Hopkinson pointed out that the experiments were quite in accordance with his theory, and that there was nothing that could not be foretold by it.

To begin with, it is necessary to get a clear idea of what is required for parallel running. It is not exactly the same as the case of alternating motors, neither is it the same as two machines of equal pressure coupled in parallel by themselves. If all the machines are coupled to two main conductors, we may consider them one at a time, and take each dynamo as coupled to a system whose pressure and variations of pressure are independent of it. Suppose the effective pressure to be 2,000 volts, for example: we have to consider a pair of mains with 2,000 volts, and we have to couple on a dynamo to add so many ampères to it. Such a machine must not be excited to give 2,000 volts on no load, being then thrown into circuit with full steam turned on immediately afterwards. It should be excited to give somwhere about half load with 2,000 volts at the terminals, and should then be thrown in. Steam can then be turned on, and the excitation raised to its normal value. The machine should be so designed that any excessive power that the engine may give shall not only not throw the machine out of step, but shall not increase the armature current to such an extent as to damage the insulation by excessive heating.

The power absorbed by a dynamo working on a parallel system is

$$P = \frac{B^2 r}{2 i^2} - \frac{A B r}{2 i^2} \cos 2 \pi n \tau + \frac{A B L}{2 i^2} \sin 2 \pi n \tau,$$

where A is the maximum station electromotive force—that is to say, the station pressure is $A \sin 2 \pi n t$ — B is the maximum "impressed" electromotive force in the armature, r is the armature resistance, i the impedance of the machine, and τ the angle of lead. This equation is taken from Dr. Hopkinson's paper. When the dynamo is doing its proper share—that is to say, under normal conditions—

$$B = I c,$$

where I is the impedance of the whole circuit when the machine is isolated, and working at full load on an external resistance, and c is the maximum value of the current. To find out how much the driving power may increase for a small increase of current, we may differentiate with respect to c, and then find the value of L which makes the result a maximum.

$$c = \sqrt{\frac{A^2 + B^2 - 2 A B \cos 2 \pi n \tau}{i^2}}.$$

$$\text{Cos } 2 \pi n \tau = \frac{A^2 + B^2 - i^2 c^2}{2 A B}.$$

So,

$$\frac{d P}{d c} = \frac{A B r}{2 i^2} \cdot \frac{i^2 c}{A B} + \frac{A B 2 \pi n L}{2 i^2} \cdot \frac{d \sin 2 \pi n \tau}{d 2 \pi n \tau} \cdot \frac{d 2 \pi n \tau}{d \cos 2 \pi n \tau} \cdot \frac{d \cos 2 \pi n \tau}{d c};$$

and in the case of a dynamo working on resistance, or on a station load when supplied with just its right share of power,

$$\cos 2 \pi n \tau = \frac{A + r c}{B},$$

$$\text{and cosec } 2 \pi n \tau = \frac{B}{L c}.$$

So,

$$\frac{d P}{d c} = \tfrac{1}{2} A + c r,$$

c being the maximum, not the effective current. It will be observed that L has disappeared altogether.

This shows that for a very small increase of power the increase of current will be the same, whatever the self-induction of the machine may be. It would not matter if the machine had none. A machine with no self-induction would (Mr. Mordey notwithstanding) short-circuit the mains if the engine supplied too little power; in fact, at full load it would be giving its minimum possible output, and any attempt to diminish this would be disastrous.

Discussing the question of a very small increase is not exhaustive; an engine may supply a large proportion more than its share of power to one machine. For instance, suppose it supplies twice the normal power. Many engines could not give such an excessive power, but in others which have expansion gear controlled by a speed governor, it is easy to get double power if the station is running at a slightly slower speed than that for which the governor is set.

These matters are always made much clearer by taking practical examples and working them out. The great difficulty is to obtain accurate data. I should prefer to discuss such machines as those described in Mr. Mordey's paper read here a short time ago. Without wishing to say anything in disparagement of his excellent paper, I must point out that an account of experiments should contain full particulars of the machines on which the experiments were made. Such omissions are exceedingly common in electrical papers. Mr. Mordey has not given us the details of the field magnets, air space, armature coils, or exciting coils; he has not even given us the currents in the different experiments. I have found similar omissions whenever I have tried to gain information from any of the numerous experiments which have been made on alternate machines in America. Mr. Mordey does, however, say that about half the drop in his machines is due to resistance, and half to self-induction. The machines give an output of 2,000 volts and 20 ampères, and when fully excited give 2,200 volts at no load. This would correspond to a self-induction of 0·05 henry.

Suppose, first, that the self-induction were such that $2\pi n L = r$: on increasing the power supply, the effective current increases evenly, and when the power supplied to the machine is doubled, the effective current is only about 44 ampères. It is necessary, however, that the machine should stand decrease of load, as well as increase, without injury. Keeping the same self-induction, let us decrease the load to zero with the full excitation on. The current gradually diminishes to just below 15 ampères, and then increases to just over 20 again.

These figures are extremely troublesome to work out from Dr. Hopkinson's equations, as the angle is so small that an error in about the sixth place of decimals will vitiate the results.

Many people prefer diagrams such as those used in mathematical books when dealing with harmonic variations. Mr. Blakesley has applied these diagrams to the discussion of alternate dynamos and motors, and Messrs. Kapp, Fleming, and others have applied them too. The chief drawback is that it is not always easy to draw such figures to scale. They are generally drawn with the values taken at random, to give ideas of the principles involved. So far as I know, no scale diagram of this sort has ever been published. In the case of the 40,000-watt machine such diagrams can be applied; but with 100,000 machines, which will probably be the standard size, the diagrams are almost illegible.

Fig. 1 is a diagram to scale. The lines are all rotating positively. The diagram is made as follows:—The pressure in the mains, A, is drawn first. Instead of the maximum, it is simpler to draw the

FIG. 1.

effective pressure—in this case 2,000 volts. From the end c, $2\pi n L\ c$ is drawn at right angles to it to f; and then $r\ c$ from f, parallel to A, B, is drawn to join the ends of A and $r\ c$, as shown. The lines are all pressures; but the instantaneous current is in step with the pressure $r\ c$ and with the pressure A, so that the power is proportional to B $r\ c \cos f\ d\ m$. I use the expression, "in step," to mean co-phasally synchronised. Thus two machines may be running at the same speed without being in step; just as soldiers may take the same number of paces per minute without being in step.

To find the current at double load, produce $i\ c$ to g, so that $d\ g = 2\ i\ c$. Through g draw a straight line, cutting B at k, at an angle, $g\ k\ d$, equal to the angle, $d\ c\ f$. The line $g\ k$ is the locus of the end of the line representing the pressure spent over the resistance and self-induction of the armature with currents giving double load. It is unnecessary to go into the proof of this. With m as centre and A as radius describe arc cutting $k\ g$ at h; join $d\ h$. Then the current at double load is to 20 ampères as $d\ h$ is to $d\ c$. In this case the double-load current is not much more than 40 ampères.

To find the current at half-load, bisect $d\ c$, and through point of bisection draw a straight line parallel to $h\ k$, and proceed as before. The no-load line, of course, passes through d.

Let us now assume the self-induction to be 0·05. The resulting diagram is shown in fig. 2. The double-load current is almost exactly 40 ampères.

Take now the case of a 40,000-watt machine with a self-induction of 0·1. At double load the current is 50 ampères, and at no load it is only 1·6 ampères. If the machine has a self-induction of much more than 0·1 quadrant, the current at double load begins to increase rapidly. It is thus clear that the self-induction may have any value between 0·008 and 0·1, and the machine will work perfectly in parallel.

We have only taken small machines. Mr. Kapp recently described a 60,000-watt machine with an armature resistance of 1·74 ohm, and a self-induction of 0·0955—say of 0·1. We may see how it will work in parallel. The pressure is 2,000 volts, and the frequency 80. This case cannot be shown clearly in a diagram, as $r\ c$ is very small in comparison with $2\pi n L\ c$ or B. The result is, however, that the machine cannot possibly take double power from the engine; it falls out of step first. Now 60,000 watts is not a large output for central stations, and it is probable that 100,000 will be about the size adopted. The "time constant" of such a machine is considerably greater. We thus find that according to the self-induction hypothesis the difficulty does not lie, as commonly supposed, in getting enough self-induction in the armature; the trouble is that there is generally too much. But in machines from 25,000 to 50,000 watts, it is exceedingly difficult to make dynamos that will not run perfectly in parallel, so great is the permissible margin of self-induction. It must be carefully borne in mind that so far the armature has been supposed to have a constant co-efficient of self-induction, and the pressures of current are assumed to vary harmonically.

The orthodox hypothesis thus tells us that with ordinary sizes of machines it is exceedingly difficult to design them so that they will not run in parallel. Either, therefore, all ordinary machines run perfectly

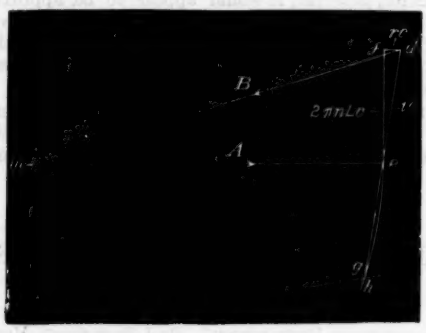


FIG. 2.

in parallel, or the assumption that alternating currents follow sine laws, that machines have co-efficients of self-induction constant throughout each period, or that they have co-efficients of self-induction constant for different armature currents, is too far from the truth to be useful; or, in legal language, one or some or any or all of them must be wrong.

PARALLEL RUNNING ACCORDING TO ARMATURE REACTION THEORY.

Last year I had the honour of reading a paper before this Institution on armature reactions in direct-current machines. In it I showed how the performance of large machines could be foretold; and the whole question of the effect of the armature current on the field magnets was discussed with some minuteness. I cannot pretend to treat alternate-current machines with the same exactness, but still a great deal is to be derived from the study.

It has sometimes been assumed that a machine has self-induction in the armature, and also that there are armature reactions to be considered, and the two actions are treated as if their joint effects had to be taken into account. This view is, I submit, erroneous. Imagine a battery with its cells connected to a number of contact pieces, and imagine the middle cell connected to a terminal, to represent one terminal of the machine, and the other terminal represented by a rubbing contact which is moved backwards and forwards over the cell contact by a crank and connecting rod. This gives the analogue of a hypothetical machine with no self-induction. If a choking coil is put in circuit, the hypothesist's alternating machine would be produced. To get a constant coefficient of self-induction in a real machine would be almost impossible. If a coil passes between two cheeks of laminated iron, its coefficient of self-induction is constant. In a dynamo, however, half the iron is cut away, the remainder forming the pole-pieces, and this remainder is not laminated. Even if a dynamo gave a curve of sines at no load, therefore, the reasoning already given would not be accurate, as L would vary considerably from one part of the period to another.

The term "self-induction" is also used somewhat loosely. Engineers do not generally think of electrical inertia now. By a

FIG. 3.

self-induction 1 in an electric circuit, is meant that if there is a current of 1 in it, it is interlinked with one line of induction. The idea of self-induction is naturally inseparable from the notion of magnetic induction being interlinked with the circuit. Another way of looking at it is to say that if the current increases there is a back electromotive force proportional to the rate of growth of the current, and

to the self-induction of the circuit. In an alternate dynamo the first definition is meaningless, because there is a field produced by the magnets; so, when the machine is still, there may be a large number of lines of induction through the armature coils without any armature current. If the second definition is taken, there is likewise an electromotive force produced by the passage through the field, apart from the effect of the armature current.

Take the case of a machine like the Siemens, with coils passing between poles. If there is a continuous current in the armature, in some positions it will assist the field magnets, and in others it will to some extent weaken them, while in intermediate positions it has no effect on the magnets as a whole. In an alternate current machine, though the armature current is alternating, relatively to the field magnets it is direct. If a series of instantaneous photographs of the armature current could be taken, each part of the air space would have its direct current.

Fig. 3 is a diagram of the field-magnet poles of a machine. There are supposed, for simplicity, to be twice as many pairs of poles as there are armature coils. If one side of a coil is between each pair of poles, if there were no armature current the fields would be inducing a maximum pressure. If the pressure curve of such a machine were

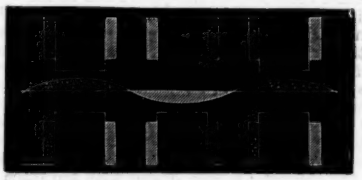


FIG. 4.

traced, and placed in the diagram of the poles, it would be as shown in fig. 4. The positive direction of the current or pressure in the armature and field-magnet coils is shown by shading, the negative by dotting. If electricity flows in the armature when the sides of the coils are in the active fields, one side of the field between the poles is strengthened and the other weakened, as shown in fig. 3. This action is fully explained in the case of direct currents in my paper already referred to; but in alternate machines the action is much more complicated, for there is no longer a continuous succession of conductors each carrying the same current as it passes any given position. If the pole-pieces were laminated, the distribution of field would vary as each conductor passed; but as it is not laminated, Foucault currents developed in the pole-pieces tend to check variations under influences varying from 200 to 600 per second. The field thus becomes stronger on one side. The curve of pressure thus gets displaced, as shown in fig. 5.

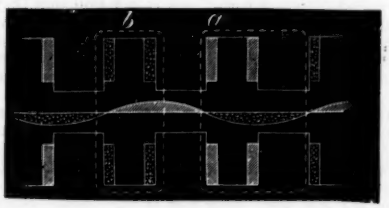


FIG. 5.

If the external resistance is non-inductive, this may be regarded as a current curve. It will be seen that each magnet is now exposed to the back induction due to the armature current. A circuit, *a*, taken round the field-magnet circuit is interlinked with the whole wave. The line integral is not changed if it is taken round any other circuit, so that the sides are the same distance apart as they are in *a*. A circuit taken as shown at *b*, however, includes only half a wave; so that from fig. 5 both the cross and the back induction could be completely worked out. In most machines it is impossible to make such a diagram accurately; but in others, such as drum armatures, with poles and coils of given widths, it is not so complicated.

The effect of the armature current, then, is first to make the current lag relatively to the position of the field magnets, and then to lessen the pressure as a whole. It thus resembles the effect of the insertion of artificial self-induction.

I think to call all this "self-induction," and to assume the harmonic law just to make calculation easy, is disguising the real nature of the action, and may lead to very serious errors. The armature reaction theory is also infinitely easier to understand, and to follow in one's head. The result of it is, in short, that if the current lags, the field is weakened; if it leads, the field is strengthened. If the current is in the direction agreeing with the electromotive force of the machine, it tends to lag, owing to cross induction; if it is against the electromotive force of the machine, as in the case of a motor, it tends to cross-magnetise the fields in the opposite direction.

(To be continued.)

Birmingham and Midland Institute Engineering Society, February 3rd, 1891.

THE CONVERSION OF MECHANICAL INTO ELECTRICAL ENERGY.

By T. ARNALL.

In the first place it may be well to define what is meant by energy, mechanical as well as electrical. *Energy* means the power or capacity of doing *work*, and it is measured by the quantity of work which it can do; and *work* is the overcoming of a resistance through a certain space. Energy map be either potential or kinetic; energy of position or energy of motion; we are going to deal with the energy of motion only. Potential energy is a very interesting branch of the subject now under consideration, but it cannot be dealt with in this paper. "Energy" and "work" are not the same things, *work* necessarily implies motion and resistance, a force overcome through a definite distance, and it is measured by the product of the force (in pounds) by the distance (in feet) through which it is overcome; *energy* does not necessarily imply motion, but it implies the power or the capacity of producing motion, and furthermore, the power of producing motion in opposition to a force tending to prevent it. When a body is thus moved against an opposing force, energy is said to be consumed; as a matter of fact, however, when the process is more closely examined, we find that instead of the energy being "consumed" it has only been transferred from one body or place to some other body or place; the usual expression is not therefore an accurate one, but it is a convenient one, and its use will do no harm if the real truth be not overlooked.

One of the established facts of modern science is that energy is indestructible; it may be transformed from one form to another in almost endless variety, but it cannot be destroyed; you may dissipate it and waste it so that it cannot be again recovered so as to do any useful work, but the sum total remains unchanged and unchangeable. Although we cannot identify any portion of energy in the same way that we can identify any portion of matter, we can in a certain way trace it in its passage from one body to another, and from one part of a body to another part; it does not disappear altogether in one place to reappear somewhere else, but it travels along definite and generally easily discoverable paths, and it is nothing but energy all along the path. It will assist us in the consideration of certain matters connected with our subject, if we examine the paths by which energy travels in several well known methods of transmitting it from one place to another.

Take the case of a pit chain used for drawing up a weight; we apply an upward pressure to the link, A, and cause it to move upwards through a certain space against the forces tending to prevent this upward movement; the pressure upon and the motion of link A are transferred to the next link, B, which is also caused to move upwards against certain forces tending to make it move downwards; link B

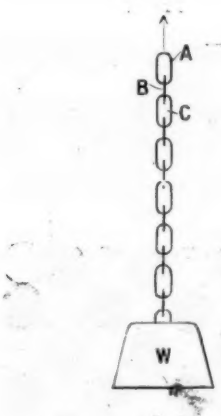


FIG. 1.

causes link C to move, and so on downwards through every link in the chain from the top to the bottom. Here, then, the weight, W, is not lifted up and work thereby done simply because the link A has been lifted up through the same space by energy having been "consumed" upon it, or put into it; but because the link A has lifted B, and B has lifted C, and so on, and because the energy "consumed" by or applied to the link, A, has been transferred to B, then to C, and so on, all down the chain to the weight, W; there has been no "consumption" of energy, but a definite transfer of it through every link; and in the potential energy of the raised up weight, W, we have the original energy applied to the top link, A. Of course, a somewhat similar argument would apply to a rope, or to a belt driving a pulley. Take now the case of a shaft, A, B, driven by a crank, A, C, and carrying a driving pulley at D. The crank pin, C, gets energy from the connecting rod of a steam engine; this causes it to move against all resistances opposing its motion through, say, ¼ of a revolution, and an amount of work represented by the pressure upon the crank pin multiplied by the distance through which it has been exerted has been put into the crank; the metal between C and A has been put under stress, of a varying amount, increasing from C towards A; the nearer A, the greater the stress, but the less is the distance through which it has to be exerted; and because of the pressure thus put upon the crank, the shaft, A, B, is made to turn. Consider any two adjacent

thin slices of the shaft, as those shown at *e* and *f*. Obviously *f* turns round because cohesive forces bind it to *e*, but, nevertheless, *e* is trying to tear itself away from *f*, to sheer itself off, and the portion of the shaft between *f* and B simply turns because of this stress between *e* and *f*, and because, moreover, *e* itself is turning round. This is only another way of saying that there is a transfer of energy from *e* to *f*; not merely a transfer of pressure, but pressure exerted through a measurable space. When we come to the pulley, D, we see that this turns round because the spokes thereof are rigidly attached to the shaft, and transmit a stress derived from the shaft onwards to the rim of the pulley; if we consider the spokes, it is a bending action, and tends to turn the rim of the pulley at right angles to them; this action or stress, in conjunction with the motion, represents work done by the inner parts of the pulley upon the outer parts; *i.e.*, it represents work "consumed" by the inner parts of the pulley in driving the outer parts; *i.e.*, it represents energy transmitted from the shaft to the rim of the pulley.

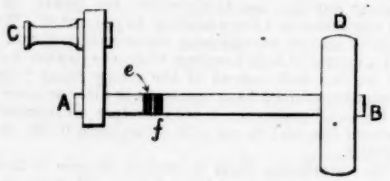
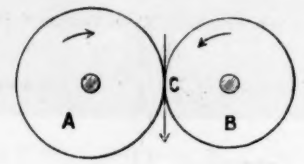


FIG. 2.

It is essential to notice that we are not dealing with the transmission of stresses or pressures; this can be effected without sensible motion taking place, but there is no transfer of *energy* effected thereby; but, so soon as the parts under stress begin to move in obedience to the forces, *then* we are dealing with energy. The particular feature that I wish to bring into prominence, is that this energy moves through a definite path and can be found as energy; *i.e.*, as pressure in conjunction with motion anywhere along this path.

At the risk of leading you to think that this stuff has not much to do with the title of the paper, I must ask you to consider another purely mechanical case of the transfer of energy. A and B are two finely toothed wheels in contact with and gearing with one another at the point C; A is being driven by its shaft, and at C it gears with and drives B and its shaft; from what has been said above you will see that energy is, as it were, flowing radially from the shaft on which A is fixed along the spokes into the rim of the wheel, and at C it flows

FIG. 3.



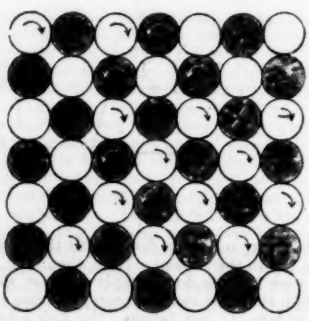


FIG. 4.

into the rim of B, and then radially inwards along the spokes to the shaft on which B is fixed. At the point, C, where the wheels gear with one another they are both moving downwards, *but the energy flows at right angles to the direction of motion;* so also does it when it flows from the shaft along the spokes to the rim of the wheel, for the spokes themselves are moving at right angles to this radial direction; so also it does when it flows from one transverse section, *e*, of the shaft considered a moment ago to the adjacent section, *f*, for both these sections are moving in planes at right angles to the axis of the shaft, and the energy certainly flows along the shaft. In the case of the chain and belt, however, the energy travelled in the line of motion. It is therefore necessary to guard against confounding the direction in which the energy flows with the direction in which the motion takes place; these directions may coincide or they may not; in the case of rotatory motion they do not.

Consider, now, the case of electrical energy; like mechanical energy it is capable of assuming several forms, but the particular form with which we are concerned is that which is associated with the electric current. There is a good deal of mystery about an electric current, and probably will be for years to come, but there are some things connected with it which we are pretty certain about and are entitled to consider as positive knowledge which future researches are not likely to upset. It is certain, for instance, that the wire conveying the current gets hot, and this points with certainty to an expenditure of energy somehow. This *may* be, because there is something moving along through the molecules of the wire, and rendering them hot by a species of friction, but it is little more than an assumption to say that this is the case. It is also certain that the wire carrying the current exerts certain actions on other wires carrying currents which may be in the neighbourhood, and it may be made to excite transient currents in neighbouring conducting bodies; and it is also certain that it has a very peculiar action on any neighbouring magnets, and even on pieces of soft iron, always tending to set the magnet in a direction at right angles to itself. In none of these cases can it be admitted that there is anything like "action at a distance." If the current in the wire acts in a certain way on a magnetic needle placed a foot away from it, the needle does not move simply because the current in the wire possesses the peculiar property of causing it to move, but because there is some adequate force acting upon it in the place where it is situated: the medium in which it lies is subjected to some strain which causes the needle to move round and take up the new position. It is quite open to argument that the action or stress comes from the wire, and spreads radially therefrom into the surrounding space, but, if so, it travels through, and by means of the medium in somewhat the same way that the pull on the top end of the chain we considered above travels through, and by means of the chain down to the weight at the bottom: the action is being exerted at all intervening points throughout the space in question. The behaviour of the magnetic needle proves that the space around the wire throughout the extent of the electric circuit is in this state of strain. An important thing to be noticed in connection with this matter is that this strain in the medium, whatever may be its nature, has *something* to do with the energy of the current; the heating of the wire represents a constant expenditure of energy which must be supplied with equal constancy from somewhere or the action would soon cease; but besides the energy concerned in the production of heat, the deflection of the magnetic needle also means an expenditure of energy. The magnetic force of the earth keeps the needle in one certain direction, and to deflect it out of this direction means the application of some sort of a pressure exerted through a certain space, *i.e.*, work done, and energy "consumed." Before attempting to form any notion of the form in which energy exists in the space around an electric current, it may be advisable to review one or two relations that are known to exist between a current and its attendant magnetic field.

An electric current is always surrounded by a magnetic field, *i.e.*, a space in which magnetic forces are found to exist. The current is known to always move in a closed circuit, and any break in the continuity of this circuit at once destroys the current. The variations in the intensity of a magnetic field may be investigated by suitable means, and it is found that the field can always be mapped out by certain lines along which the magnetic force appears to be exerted: these are called "lines of force," and it is found that they are always closed curves, and they always surround the electric current. The current passes through the closed curves of the lines of force, and the lines of force in their turn pass through the closed curve of the electric circuit: the two are interlinked, like the two consecutive links of a chain. A current of electricity is the same in quantity all through the circuit: so also the lines of force; if we find the magnetic field more intense in one place than in another, it means that in the place where it is the more intense there are more lines of force passing through a given area, and between this place and the place where it is less intense some of the lines of force have strayed and are passing through some other part of the space. Since every line of force forms a closed curve, it follows that it can never end at a point in space. It is further observed that the lines of force act as though they repelled one another, and also as though there was a tension along them tending to make them shorter and to close up on the circuit. We also know that when a conductor is moved through a magnetic field, so as to cut through the lines of force, an electromotive force is set up within it tending to cause a current in a certain direction, and this current will be formed if the conductor be such that a current can exist within it, *i.e.*, if it forms part of a closed circuit. These things may be taken as facts, and altogether independent of any hypotheses devised to explain them.

We now have to form some adequate notion as to what is really going on in a magnetic field, and what is the nature of the forces and the movements (if any) within it. It is soon settled that the air has nothing to do with it, for all the magnetic actions go on just the same in a vacuum: if then it is not the air, we conclude that it must be the ether, for this is known to exist in a vacuum as well as everywhere else, and this must be the medium if the magnetic field depends upon any medium at all.

Here I feel to be treading on delicate ground; this is a society of engineers, and so long as an engineer is dealing with steel and iron, brickwork, concrete, earthworks, and such like, he is dealing with things that properly belong to his profession. It is also quite proper for him to take up such questions as hydraulics and compressed air, and in recent years some applications of electricity have been included within the sphere of his duties; so long as it is called "electricity," an engineer may not object; but when you come to mention such a transcendentally attenuated material as the luminous ether, it is likely that he will kick against it, and deny that he has any concern whatever with it. I want to show that this view is altogether wrong, and that in the future the average engineer may have to take account

of and deal with the strains in the luminiferous ether in the same cool matter-of-fact way that he now does with the strains in a line of shafting and a few leather belts. It is not possible to reason about phenomena connected with the ether without introducing some theory of its structure, and any claim such a theory may have to acceptance, will depend entirely upon whether or not it affords a reasonably satisfactory explanation of a vast array of facts that call for an explanation. The following notions as to the structure of the ether, may or may not be true, but it should be plainly understood that the ether itself is an unmistakeable reality, and the strains and stresses that may be set up within it are very eminently practical things for the engineer to concern himself about.

When we come to consider the ether by itself, we at once come upon a set of facts and figures that "boggle the imagination." For instance we take a second as a convenient small unit of time, fairly well suited to our nature; if one sound follows another at an interval of one-twentieth of a second or thereabouts, we cannot detect the interval, and reckon the two sounds as one; the eye is even less sensitive to intervals of time than this, while our thoughts move at such a muddy sluggish rate, that before we are conscious that any time whatever has elapsed a wave of light in the ether has had time to repeat itself 25 millions of millions of times over. These waves travel through the ether at a speed a million times greater than that of sound in air, with which we are more or less familiar. Compared with air the density of ether is almost infinitesimal, but its elasticity is very high, and it pervades the space occupied by ordinary matter, solid, liquid, and gaseous, almost as though that matter were not there. It is really impossible for us to realise these and many other things about the ether which we have reason to believe are true; this difficulty does not arise from any improbability in the things themselves, so much as from the fact that the ether is not classed among material ponderable bodies, and many of the figures connected with it are of quite a different "order of magnitude" to those connected with such bodies, and therefore beyond the reach, so to speak, of our senses.

There are two theories of the constitution of the ether; according to one it is a sort of ultra-gaseous matter, composed of little particles rushing about in all directions, very much like the particles of a gas, but differing therefrom in being inconceivably more minute, and having an immensely higher velocity. This theory has been admirably worked out in Mr. Trevor Preston's book on "The Physics of the Ether," a book well worth studying, even by engineers. The other theory is not quite so definite, and is not so easy to explain or to understand; nevertheless it is the one we have to deal with, because it affords by far the most satisfactory explanation of the facts of electricity and magnetism. According to this theory the ether may be likened to a solid, a liquid or a jelly according to the particular properties under consideration. It is like a solid in being extremely rigid to shearing stress and electric forces tending to cause distortion; it is like a liquid, for it allows material bodies to pass through it without offering any measurable resistance, and again, in studying the properties of insulators it is hard to dissociate the facts from the idea that the ether is really a kind of jelly.

We cannot go fully into these matters in a paper like this, and I must be content with asking you to consider the structure of the ether to be something like this. We must imagine it to be made up of two distinct, and in many respects, widely differing constituents and there is reason to believe that one of them is what we know as positive electricity, and the other one is negative electricity; the two together in combination we call the "ether," separate we call them "electricities." The molecules of ether are normally at rest, not rushing about like the molecules of a gas; the two electricities are latent as it were, and any force tending to separate them we call an "electromotive force." In free space, and in insulating bodies, the particles are all locked together in some way and resist any force which tends to separate them, in conducting bodies this locking together does not exist, and the particles are free to move about in obedience to an appropriate force, not quite freely, but only restrained by a species of friction.

Fig. 4 is a diagram of what is meant by this structure, the shaded circles are intended to represent the particles of positive, and the unshaded circles particles of negative electricity; note that every particle of positive is in contact with four of negative, and every negative with four of positive, and negative is nowhere in contact with negative nor positive with positive.

It is very difficult to separate these particles so as to make one slide over the other; the force doing this, or tending to do this, is what is called an electromotive force, and the great resistance the ether in free space and in insulating bodies offers to such a force conveys the idea of it acting like a solid; but although it is so difficult to shear the particles asunder, it is very easy to get them revolving, rolling round in contact with each other, or gearing together like so many cog wheels; this species of motion is easy in such a medium as the one represented, because it does not set up anything of the nature of a shearing force between the contiguous particles; shearing involves a sliding of the particles past one another, a revolving or rolling motion does not. The force that causes this rotation is called a *magnetic force*, and the resulting state of the ether is called a *magnetic field*. In a magnetic field all the positive particles are revolving one way, and all the negative particles the other way: whatever action a clock wire rotation in a positive particle may have on neighbouring bodies is precisely the same as a counter clock-wire rotation in a negative particle, and the polarity of the field is simply the contrary aspects of this rotation; what is north polarity on one side of the rotating wheels is south polarity on the other side.

Consider a slice of the ether, such as is shown in fig. 4, and suppose the magnetic force has set all the wheels spinning as indicated by the little arrows; what will be the effect on the layer of particles immediately below the one shown in the diagram? In a state of rest every positive particle will have a negative immediately below and above it, and every negative will be over and under a positive, so that a vertical section would show the same structure as fig. 4, which we may suppose to be a horizontal section. But the magnetising force sets all the positives spinning clockwise, and the negatives in the contrary direction; we shall therefore have the positive and negative particles in the diagram rotating in the opposite direction to the particles immediately above and below them; not rolling on one another in the same plane, but rubbing past one another in parallel planes, *i.e.*, with a shearing force between contiguous molecules. As this cannot go on, the magnetising force has a further effect on the medium, the adjacent planes of particles are shifted in a minute space laterally so as to bring the positive particles all into lines coincident with the axis of rotation, and similarly all the negatives also. Every centre of rotation in fig. 4 therefore represents an axis perpendicular to the paper, and the structure of the ether is modified so as to bring all the positive particles into definite lines or filaments, the negatives similarly into filaments parallel with them, and the magnetic field is a mass of these filaments rolling round in contact with one another, every positive filament being in contact with four negatives, and every negative filament in contact with four positives.

This is a very rough picture of the structure of a magnetic field; several important consequences at once follow from it. It is evident that none of the filaments can end at a point in space, for if it did we should there have friction and shearing forces called into play; it would be something like the friction of a pivot on its bearing. The only way to avoid this is for the threads to return into themselves, *i.e.*, to form closed curves. This is exactly what we know to be true of a line of force. Again, in any line of force, the magnetising force may be applied all along the line, or at some point only; in the latter case the natural tendency will obviously be for the chain of positives, say, particles, to complete itself through as short and as easy a path as possible; that is to say, the lines of force tend to shorten themselves. Again, there will be something like a centrifugal force all along the lines, which will tend to cause them to expand and push one another further; this, also, we know to be true, and the action may almost be seen going on in the picture of the lines of force which is made by sprinkling iron filings on a card near a magnet. Another thing to bear in mind is that it requires an "expenditure" of energy to set up the lines of force in a magnetic field; every one of them represents a store of energy, and the line cannot be broken or destroyed without that energy manifesting itself in some way.

It may not be out of place to review these statements; we have arrived at the conclusion that the magnetic field is composed of lines of force, the ether in the form of filaments of the two electricities rotating round the axes of these lines, the filaments gearing sideways and rolling round in contact with each other; every line of force a

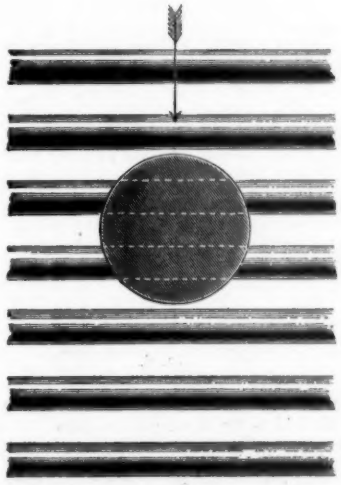


FIG. 5.

store of energy; the lines of force repelling one another and tending to push themselves further apart; and finally, a sort of tension along the lines, tending to bind the particles of positive and negative electricity respectively together.

Observation shows that every electric current is surrounded by a magnetic field, and that the lines of force belonging to this field are concentric circles around the wire; from what has just been said, then, it follows that the ether around an electric current is in motion in a series of concentric vortex rings; that these vortex rings require energy to set them up in the first instance; they represent a store of energy, and cannot be destroyed without setting that energy free. The magnetic field is so prominently a part and parcel of whatever we mean by an electric current, that some people even go so far as to say that it *is* the electric current. This view I do not share in, but for our purpose to-night this is the only property of an electric current that really concerns us; and we may consider the current to be the concentric series of vortex rings around the wire.

Return now to the lines of force: fig. 5 is another section of the magnetic field at right angles to the former one, and along the lines of force instead of across them. The positive filaments are shown by the shaded cylinders, they should of course alternate and be in contact with negative filaments which are not shown. In the figure a part

of the field only is shown; it will be understood that the lines are parts of closed curves which return into themselves through paths outside the limits of the diagram. The shaded circle is intended to show the section of a wire which forms part of some closed up circuit. Let us consider what will happen if we force the wire through the lines of force in the direction of the arrow. If the ether in the substance of the wire were in exactly the same state as it is in the open air, and if the wire could move through it without friction or anything analogous thereto, there would be no reason to expect that anything would happen. But we know that in the open air the ether is bound up in some way, and that the lines of force are definite filaments in it with something in the nature of cohesion or tension along their length, and we have also reason to believe that in the substance of the wire the ether is comparatively free, the particles only acting upon one another by a species of friction: left to themselves, the lines of force that happen to cut through the wire will form themselves all right, except that in the wire, instead of the rigid end-on connection between the contiguous particles composing a given line there is only a loose frictional coupling; and sideways, instead of locking together like wheels in gear, we have only a frictional contact where slip may easily occur. Every line of force then that enters the substance of the wire has to be severed, and it will take some little time to complete itself across the gap in the metal by means of the friction between the particles of ether that now form part of its path. As the wire advances, then, in the direction of the arrow the lines of force in front of it oppose its motion, before they can be broken they have to be stretched as it were, besides being pushed forward and crowded up together: their natural repulsion opposes this again, and so, before the lines of force actually in contact with the wire are ruptured, others in advance of them are crowded up together. Behind the wire we shall have the lines thinned out and pulled apart. The net result of all this is that in front of the wire we have an excess of energy and motion, and behind it there is a deficiency; as a consequence of this, we shall immediately have a flow of energy set up from the front of the wire round to the back. The excess in the spin round the lines of force in front of the wire will tend to equalise itself by spreading round to the back of the wire. It is not easy to show in a diagram the details of this action, but the result is so important that it may be worth while to make the attempt.

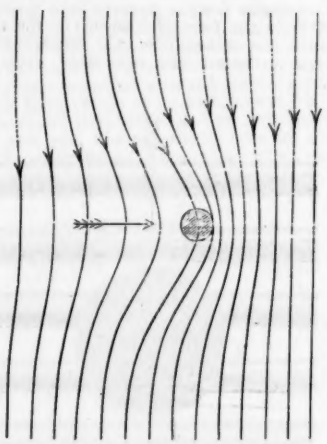


FIG. 6.

Fig. 6 is intended to show on a much smaller scale the same section of the magnetic field as fig. 5, the positive lines of force being represented by mere lines. The arrows on the lines are intended to show the direction of rotation in the ether along the lines in accordance with the following covention. Suppose you look direct at the face of a clock, the direction of rotation round the line joining the eye with the centre of the dial will then be indicated by an arrow pointing from the eye towards the dial if the rotation is in the same direction as the hands of the clock; if the rotation is in the opposite direction, it will be defined by an arrow head pointing from the dial towards the eye. In this way, then, the arrow heads define the direction in which the positive constituent of the ether is rotating round the lines of force shown in the diagram, and the lines are shown crowded up in front of the moving wire and thinned out behind it, as before described; an excess of energy on the one side, and a deficiency on the other, and as a consequence a tendency for the excess of energy on one side to pass round to the other side.

Consider, now, fig. 7. This shows the lines of the field straight, and in amongst them another set of concentric circular lines around the wire; the small arrow heads define the direction of rotation of the positive constituent as before described. Obviously, the circular lines on the advancing side of the wire coincide in their direction of rotation with the lines of the field; on the opposite side they are in the opposite direction; the net result is the same as that shown in fig. 6, an excess of spin in front of the wire, and a deficiency behind it. But evidently the circular lines constitute an electric current in the moving wire, being the lines due to the circular magnetic field inseparable from the current, the lines of the original field apparently remaining intact. The result, then, of pushing the wire through the magnetic field is first to distort the lines of the field and thereby to excite an opposing force to the motion of the wire, and, secondly, to generate in the wire a current of electricity, this being equivalent to the distortion of the field.

Objection may be made that the field will either be as shown in fig. 6 or as in fig. 7, but it cannot be both. I would submit that it *can* be both, for the following reasons. When, in mechanics, a body is simultaneously acted upon by two forces, it is found to move along a certain path determined by the principle of the parallelogram of forces; this path is not the same as that which the body would have described if left to the action of either of the forces, so that it may be said to have obeyed neither of them. It has, however, really obeyed both of them, and the resulting position of the body at any instant is exactly the same as though it had been acted upon by one force first, and then by the other one. Thus, while the body apparently obeys neither force, it is really obeying both. It is so with the ether around the wire; any particle of it at any instant is

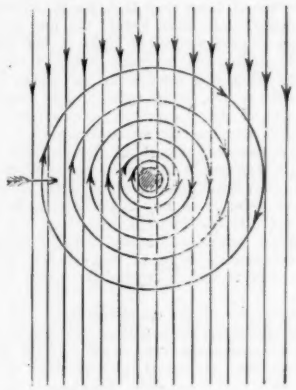


FIG. 7.

called upon to obey two forces, one due to the magnetisation of the original field, the other due to the induced current in the wire; in obeying neither the result is precisely the same as though it obeyed both, and that result is, the original field plus a current in the wire.

The principles that have been laid down lead to further results. Fig. 8 is another section through the magnetic field along the lines of force, but along the wire instead of at right angles to it, as in fig. 7. The circular vortex rings, due to the induced current, are now cut through above and below the wire, and show in the section as little circles, rolling round in contact with one another, every circle being a section through a vortex ring concentric with the wire. The wire is carried out beyond the limits of the magnetic field on both sides, the lines of the field being shown by the vertical lines as in fig. 7,

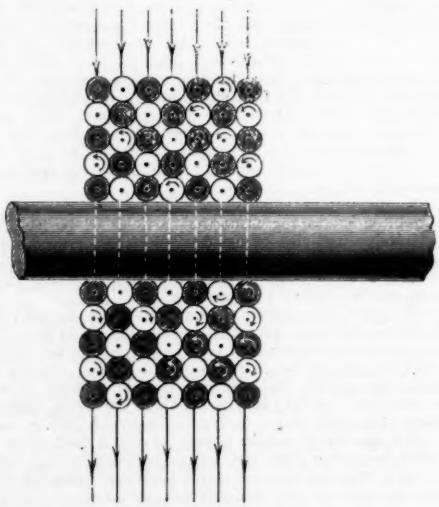


FIG. 8.

these lines being dotted through the wire itself to indicate the imperfection in the continuity of the lines. We have formed a rough notion as to how the rings are set up within the field by the lines thereof being crowded up on one side of the wire, and thinned out on the other side; outside the limits of the field there are no lines to crowd up, the ether is perfectly quiescent, but evidently the vortex rings at the edge of the field cannot roll round without spreading the motion out sideways and beyond the limits of the field itself. If this did not happen, we should have continuous friction where the vortex rings came into contact with the quiescent ether, and the motion therefore is propagated onwards throughout the whole extent

of the circuit. We have here then a reason why the circuit must be *closed*; if it were not so, wherever the break occurred we should there have friction of the vortex rings against the ether, all motion immediately arrested, and only an electrostatic strain produced; with a continuous circuit only can a continuous motion of the vortex rings be possible.

This motion is what we recognise as being really the electrical energy of the current. It is clear that a continuous "expenditure" of energy is required to keep it up, for consider the inside of the vortex rings immediately in contact with the wire; there is no gearing with the ether inside the metal, only a frictional kind of contact, and a resistance to motion offered in some way by the molecules of the metal; the result is a slipping of the wheels on the surface, positive electricity being dragged along in one direction, and negative in the other direction, and a production of heat due to the friction. This heat means a continuous expenditure of energy, which must be drawn out of the vortex rings; owing to the friction it is not so easy to keep them going as it otherwise would be; they have to be *forced* round against the friction. This puts a back pressure upon them, as it were, and instead of being easily generated in the magnetic field, they have to be generated in opposition to this back pressure; this means a greater crowding up of the lines of the field than would otherwise be necessary, and a correspondingly greater mechanical pressure applied to drive the wire through the field, and power is required not only to move the wire through the field, but to set up and maintain the system of vortex rings throughout the extent of the circuit, and to keep them going in opposition to the resistances they encounter at the surface of the wire.

This is what we are to understand by the conversion of mechanical into electrical energy; the mechanical energy is tangible enough to an engineer, and by the theory of the ether which has been very roughly given in outline, it may be seen that electrical energy is not, after all, such a very intangible affair, nor the conversion of the one kind of energy into the other altogether incomprehensible; it is a thing which an ordinary engineer ought to understand, and be able to make use of as occasion requires. It is clear that mechanical and electrical energies are both really quantities of the same kind, the one being energy of material bodies and the other energy of the ether. The mechanical energy is not converted into electricity; it remains nothing but energy all the time; *i.e.*, something in motion and capable of doing *work*. It also follows that the energy of the electric current is not *in* the current, it is not in the stream or streams of electricity being dragged along the wire; it is in the surrounding ether, and the current is drawing it out and dissipating it in the form of heat.

The path along which the energy flows is readily seen; the axis of any vortex ring is a circle round the wire; the ether is moving round this axis everywhere in a plane at right angles to it at the point considered; energy is picked up on one side of the ring and handed out at the other, thus travelling at right angles to the axis, precisely as in the case of cog wheels on parallel shafts. Some of the energy passes inwards towards the wire to maintain the motion against the friction on and within the metal, the other part is passed on along the circuit paralled to the wire, but always at right angles to the whirls in the ether engaged in transmitting it.

So much for the conversion of mechanical into electrical energy; the converse problem, viz., the conversion of electrical into mechanical energy, follows almost as a corollary from what has been said. Suppose the electrical energy to be coming in along the wire, a portion of which is immersed somewhere in a magnetic field, as shown in figs. 7 and 8. The vortex rings belonging to the current add their spin to the ether on one side of the wire, and subtract it from the lines on the other side; the consequence is that the wire is forced backwards in a direction contrary to that of the arrow. If there be any resistance to this motion, the resistance will be overcome if there be energy enough coming in along the wire (*i.e.*, if the vortex rings are being driven with sufficient power at the other end), *and also*, if the lines of the field are stiff enough to afford the necessary back pressure. If the resistance *be* overcome, work is done and energy "consumed;" *i.e.*, it is transferred from the vortex rings to the body offering the resistance; if it be not overcome, there is no energy transferred, only a state of strain produced.

It will be noticed that there are three essential things involved in these processes. We have, 1st, the mechanical energy in the moving conductor; 2ndly, the lines of force in the magnetic field; and, thirdly, the resulting electric current with its electrical energy in the vortex rings. From the mechanical energy and the magnetic field we get the electrical energy; and from the electrical energy and the magnetic field we get the mechanical energy; in both cases we must have an independent magnetic field. Its lines of force form a sort of abutment, or they may be likened to the fulcrum of a lever; at one end we have the mechanical energy, at the other end the electrical energy, and like the levers in mechanics, the energy at the one end is the same as that at the other, but neither is available without the fulcrum.

In conclusion, it is right for me to say that the chief basis of this paper is Prof. Oliver Lodge's book on "Modern Views of Electricity," being largely an expansion of some of the ideas therein; and I cannot help thinking that the time is close at hand when it will be found quite necessary to set about re-writing some of our text-books of electricity, and making them more in accordance with the *principles* (not necessarily the *details*) of the theory of electrical energy which I have endeavoured to put before you.

Physical Society, February 13th, 1891.

ANNUAL GENERAL MEETING.

(Prof. A. W. REINOLD, F.R.S., Past President, in the Chair.)

THE reports of the council and treasurer were read and approved. From the former it appears that there has been a satisfactory increase in the number of members, and in the average attendance at the meetings. During the year a translation of Prof. Van der Waal's memoir on "The Continuity of the Liquid and Gaseous States of Matter" has been issued to members, and it is hoped that the translation of Volta's works, now in hand, will be published before the next general meeting.

The council regret the loss by death of Mr. W. H. Snell and Mr. W. Lant Carpenter, and obituary notices of these late members accompany the report.

The treasurer's statement shows that the financial condition of the Society is very satisfactory, and that the sales of the society's publications have increased considerably.

A vote of thanks, proposed by Mr. WHIPPLE, and seconded by Dr. GLADSTONE, was unanimously accorded to the Lords of the Committee of Council on Education for the use of the room and apparatus.

Dr. ATKINSON proposed a vote of thanks to the auditors, Prof. Fuller and Dr. Fison, which was seconded by Dr. THOMPSON, and passed unanimously. The proposer, in referring to the satisfactory nature of the accounts, recommended that the publications of the society should be brought before physicists and other students of physical science, and Dr. Thompson heartily concurred in this recommendation.

A third unanimous vote was accorded to the president and officers for their services during the past year, the proposer and seconder being Dr. WALLER and Prof. MINCHIN.

The following gentlemen were declared duly elected to form the new council:—President, Prof. W. E. Ayrton, F.R.S.; Vice-Presidents, Dr. E. Atkinson, Walter Baily, M.A., Prof. O. J. Lodge, D.Sc., F.R.S., Prof. S. P. Thompson, D.Sc. Secretaries: Prof. J. Perry, F.R.S., T. H. Blakesley, M.A., M.Inst.C.E. Treasurer: Prof. A. W. Rücker, M.A., F.R.S. Demonstrator: C. V. Boys, F.R.S. Other members of council: Shelford Bidwell, M.A., LL.B., F.R.S., W. H. Coffin, Major-Gen. E. R. Festing, R.E., F.R.S., Prof. G. F. Fitzgerald, M.A., F.R.S., Prof. J. V. Jones, M.A., Rev. F. J. Smith, M.A., Prof. W. Stroud, D.Sc., H. Tomlinson, B.A., F.R.S., G. M. Whipple, D.Sc., James Wimshurst.

The meeting was resolved into an ordinary science meeting, and Messrs. W. Thorp, B.Sc., G. W. Yule and S. Joyce were elected members of the society.

Prof. MINCHIN showed some experiments in illustration of his paper on "Photo-Electricity," read at the previous meeting. In one of these, a seleno-aluminium battery, illuminated by the light of a taper, deflected an electrometer needle, thereby actuating a relay and ringing a bell. He afterwards exhibited one of his "impulsion cells" in action, and showed the change from the insensitive to the sensitive state produced by a Hertz oscillator at a distance.

In the discussion, Mr. TUNZELMANN said Kalisher and Von Uljanin had worked at the same subject, the former being the first to make experiments on a photo-E.M.F. in selenium. His cells were made by winding brass wires on glass tubes and coating them with selenium, which was subsequently annealed. These cells lost their power after some time, and would not respond to feeble lights. By using two wires of different metals he obtained better results. Fritts, in 1883, used brass and gold plates coated with selenium, and Uljanin employed platinum plates deposited so thin as to be transparent. The latter experimenter found that the E.M.F. was proportional to the square root of the intensity of the light. He also observed that the orange-yellow of the prismatic spectrum produced the greatest effect, whereas the yellow-green and the green rays of the diffraction spectrum gave the maximum E.M.F. Comparing these results with Langley's observations on the energy of the spectrum, it would appear that the E.M.F. bears no relation to the maximum energy falling on the surfaces. Speaking of the cause of the phenomena, he said the electrolytic idea of Von Uljanin seemed inapplicable to Prof. Minchin's results, and he enquired whether a mixture of selenium and aluminium would undergo a gradual change by exposure to light.

Dr. GLADSTONE said such a change, if it occurred, would be very slow, for nearly all difficult chemical reactions take time to complete. The fading of colours was adduced as an instance of slow chemical change produced by light.

Dr. WALLER thought the subject might throw light on the changes occurring in the retina, and asked if it was possible to separate thermo-electric and photo-chemical effects.

Dr. BURTON said he had suggested that the action of light on the retina was a photo-chemical one some time ago. But hitherto it had been difficult to obtain substances sensitive to any but the blue and violet rays, whereas the eye was most sensitive to green and yellow light. In the photo-electric batteries, however, the E.M.F. may generate a current, and therefore energy, and the important question seemed to be, Where does this energy come from? Is a chemical change precipitated by the action of light, or does a direct conversion of light into electric energy occur?

Prof. MINCHIN, in his reply, said he thought his cells really transformed the incident energy. They were usually kept on open circuit, and there appeared to be no deterioration with time, the only change being a sluggishness in developing their maximum E.M.F.

LONDON COUNTY COUNCIL.

AT the meeting on Tuesday last, the Parliamentary Committee reported as follows:—

General Powers Bill.

We have to report for the information of the council the following list of petitions which have been presented against the General Powers Bill:—Brush Electrical Engineering Company and other

Electric Lighting Companies; Corporation of London; East London Water Works Company; East and West India Dock Company, and London and India Docks Joint Committee; Great Eastern Railway Company; Gas Light and Coke Company; Henry George Hills; North London Railway Company; Vestry of Lambeth, and the Wandsworth District Board of Works.

London Overhead Wires Bill.

Ten petitions have been presented against this Bill, viz.:—From the Commissioners of Sewers of the City of London; East London Railway Company; Society of Lincoln's Inn; the Inner Temple; the Middle Temple; London, Chatham and Dover Railway Company; Metropolitan Railway Company; Metropolitan District Railway Company; St. Giles District Board of Works, and the National Telephone Company.

Central London Railway Bill.

The following is a list of the petitions presented against this Bill:—London County Council; Frank Willan and others; Duke of Westminster; Gas Light and Coke Company; Vestry of St. George, Hanover Square; Vestry of St. Marylebone; Vestry of St. Mary Abbotts, Kensington; Vestry of Hammersmith; Vestry of Paddington; Trustees of the late Duke of Portland; Ecclesiastical Commissioners; Saint Giles District Board of Works; Viscount Portman; Westminster Electric Supply Company; City and South London Railway Company; Maurice Powell; Great Western and London and North-Western Railway Companies; Edward Bird and others (Governors of Latymer Foundation at Hammersmith); Corporation of London; Commissioners of Sewers of City of London; London, Chatham and Dover Railway Company; Owners, &c., in Cornhill and Cheapside; Trustees of the Paddington Estate and others; Metropolitan Railway Company; Dean and Chapter of St. Pauls; Owners, Lessees and Occupiers; Commercial Union Assurance Company.

City and South London Railway Bill.

This scheme has been petitioned against by the following—London County Council; Gas Light and Coke Company; Lord Calthorpe; Ecclesiastical Commissioners; Corporation of London; Commissioners of Sewers; New River Company; Messrs. Rothschild & Sons; Vestry of St. Luke, Middlesex; Regent's Canal, City, and Docks Railway Company; Metropolitan Railway Company; London Hydraulic Power Company; Betts & Co.; Governor and Company of Bank of England; North Metropolitan Tramways Company; Cooper Brothers and Co.; Metropolitan District Railway Company; Union Bank of London.

South Kensington and Paddington Subway Bill.

The following is a list of the petitions against the Bill—London County Council; Gas Light & Coke Company; Vestry of St. Mary Abbott's, Kensington; Great Western Railway Company; Ecclesiastical Commissioners: West Middlesex Water Company; Vestry of Paddington; East London Water Company; Grand Junction Water Company; Metropolitan Railway Company; National Telephone Company; City and Guilds of London Institute, &c.; Commissioners for the Exhibition for 1851; Trustees of the Paddington Estate and others; Metropolitan Electric Supply Company; Metropolitan District Railway Company.

The following is the report of the Highways Committee:—

Notices under Electric Lighting Orders and Acts.

We have considered a notice (Registered No. 160), dated February 11th, 1891, from the London Electric Supply Corporation, of intention to lay trunk mains across Cockspur Street and into Red Lion Yard, where the company has a distributing station (one plan). There appears to be no objection to what is proposed; and we recommend that the sanction of the council be given to the laying of the trunk mains referred to in the notice (Registered No. 160), dated February 11th, 1891, from the London Electric Supply Corporation, upon condition that the company do give two days' notice to the council's chief engineer before commencing the works; that the mains, where laid under the footways, shall be kept 2 feet below the underside of the paving, and, where they cross the carriageway, at the same depth below the concrete, or if this be found to be impracticable, that the mains be protected from mechanical injury to the satisfaction of the council's chief engineer.

Subways.

We have considered an application with a plan from the Universal Telephone Company for permission, to run two wires, twisted together, in the subway of Northumberland Avenue, for the purpose of establishing communication between the Hotel Metropole and the Grand Hotel. There appears to be no objection to this proposal; but we are of opinion that the company should be called upon to pay a small rent for the use of the subway for the purposes of its business. We recommend that the Universal Telephone Company be allowed, during the pleasure of the Council, to run two wires, twisted together, in the subway of Northumberland Avenue, as shown upon the plan submitted by the company, upon condition that the positions in which the wires shall be placed in the subway shall be determined by the Council's chief engineer; that the space occupied by them shall not exceed that which would be taken up by a 2-inch pipe; that the work of placing them shall be carried out, and that any damage that may be done to the subway in the execution of the work shall be made good, to the satisfaction of the Council's chief engineer, and at the cost of the Company; and that the Company do agree to pay a rent of £1 a year in respect of the use of the subway during the time that the wires remain there.

PARLIAMENTARY NOTES.

TELEGRAPH REVISION SCHEME.

EARL COMPTON asked the Postmaster-General whether he could state at what date the revision scheme in telegraph offices throughout the United Kingdom would be completed.

Mr. RAIKES: The revision scheme to which the noble lord apparently alludes was carried into effect in July last. The corollary measure, which is independent of that revision, and only deals with a comparatively small number of superior officers, is now engaging the attention of the Treasury.

LIVERPOOL CENTRAL TELEGRAPH OFFICE.

EARL COMPTON asked the Postmaster-General whether the Central Telegraph Office buildings at Liverpool were unhealthy and unsatisfactory, and if so, what steps he intended to take in the matter.

Mr. RAIKES: Assuming that the noble lord is referring to the head post office at Liverpool, I have to state that the special inquiry mentioned in my reply of December 8th last to the hon. member for the Kirkdale Division has been made, and that the whole subject is now under the consideration of the Treasury.

NOTES.

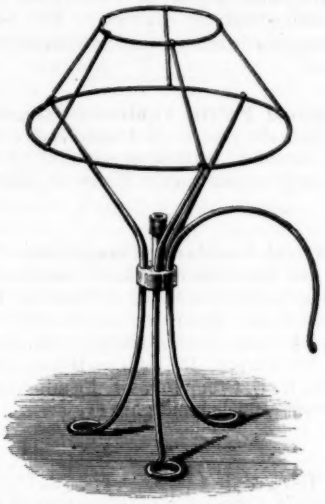
The Spanish-Morocco Cables.—The Spanish journal, *El Liberal*, recently announced the arrival (on February 13th), at Almeria, of the Italian cable steamer the *Citta di Milano*, carrying a portion of the cables manufactured by Messrs. Pirelli & Co. for the Spanish Government and which are to be laid along the Morocco coast, and between that coast and Spain. It was stated that on the expedition under notice the sections betwen Almeria and Alboran, and Alboran and Melilla were to be laid. We are also informed that the cable hut on Alboran had been completed, and that the telegraph station was in course of construction. The Spanish gunboat *Isla de Luzon* has been detailed by the Government to escort the cable steamer during the operation of submerging the cable. The cable communications about to be established present, outside Spain, no features of general interest, except perhaps the fact that facilities will be now afforded for vessels to telegraph when passing the island of Alboran; this accommodation may possibly be of some service. The places on the Morocco Coast, which it is proposed to connect by submarine cable, may be described as purely convict settlements and prisons, but it is easy to understand that Spain may wish to establish a firmer hold on the shores of a territory she has long coveted; hence the accomplishment of the long desired telegraph communications.

Storms and Telegrams.—It is stated in the portion of this paper published in last week's issue, that the Post Office cables are made in lengths of 200 yards, and are drawn from a flush box in the middle, 100 yards each way. Consequently, joints are to be met with every 200 yards. These cables have (unless changed very lately) been always made in lengths of 400 yards, and flush boxes are placed at every 100 yards (more frequently when curves, &c., are met with), the cable is coiled down at the 200 yard box, and the ends are drawn each way; one end of 200 yards is first drawn through to the 100 yard box, and the end drawn out, the cable is turned over to get the end up, and it is then drawn to the joint box. The opposite portion of 200 yards is then drawn to No. 3 box, treated similarly, and its end carried through to No. 4, or second joint box. Thus, in dealing with a 400 yard length, there is a little more trouble, but extra joints are avoided.

Electric Lighting at Cannes.—The Cannes Electric Lighting Company has been formed at Lyons to work a concession given by the Cannes municipality for twenty years, the exclusive right to supply light and power being for eight years. The power will be obtained from the Sianne canal. Subscriptions to the extent of 5,500 incandescent lamps have already been received.

Electric Traction in Breslau.—The present tramline will shortly be converted into an electric tramway on the overhead system

The "Webber" Electric Light Fitting.—The fitting illustrated has been designed by General Webber, and is manufactured (solely) by the Blockley Electric Lighting and Manufacturing Company. As will be seen from the woodcut, it is of very simple construction, and is available either as a standard or a bracket, and an arm with which it is provided fits it for attachment to the back of an easy chair or any similar position. It is lightly but substantially made of brass rod and is supplied either with or without a wire frame for a shade. It is supplied in two sizes, 12 inches to top of shade, and 18 inches.



Advertising by Electromotor. — The *Elektricitäts Zeitung* states that a small electric motor has been installed in the window of a Berlin lottery firm. The motor drives a lottery wheel, and the current is obtained from the Berlin Electricity Works.

Madrid Lighting.—From advices just to hand, we learn that the electric lighting of the Senado (corresponding to our House of Lords) which is supplied with current from the mains of the Electricity Supply Company for Spain, Limited, was, on Wednesday night, witnessed by the Queen and suite. The Queen expressed her great satisfaction at the illumination. It will be remembered that the system employed by this English company is that of the high tension alternating current transformer type, whose station is outside the city, and is on the model of the House-to-House Company's station at West Brompton.

Electric Indicator.—In reply to a letter of "L. B.," asking for information about a particular electric indicator, Messrs. Yeates, of 2, Grafton Street, Dublin, say that they are makers of every kind of indicators, including the one mentioned by our correspondent. Messrs King, Mendham and Co., Bristol, have written us to the same effect.

Newspaper Science Repeated. — Not long ago, the *Times* contained a detailed account of the production of water gas at the Leeds Forge. As everyone might have supposed, the publicity was simply the prelude to financial operations. In this case it happened to be a speculative affair of colossal proportions. In due time the subject came within the domain of the City Editor, and was then properly handled, with the result that an unseemly controversy ensued between the parties interested in the promotion of the schemes and the *Times*. The unfavourable opinion of the City Editor was confronted with the favourable opinion of the contributor, and the latter, of course, regarded (by the interested parties) as the more correct. On Wednesday, the *Times* contained a report of the Elmore visit, and it will be interesting to note if history repeats itself. Perhaps a double lesson will teach the *Times* that its duty to the public is not performed by giving prominence in its columns to reports of industrial inspections, which may just as well be prepared by the interested parties as by one of the technical contributors, by whom the *Times* is generally supposed to be represented on such occasions.

Liverpool Corporation Assistant Electrician.—The Lighting Committee of the Liverpool Corporation, at their meeting on the 9th inst., had before them a proposition to appoint a general assistant to the electric inspector, who would be required to assist in both clerical and technical work. This is due to the rapid increase in the amount of electrical testing and inspectional work carried out by this department, which has followed upon the extended operations of the Liverpool Electric Supply Company, Limited. After some discussion, Mr. Herbert James Roscoe was unanimously appointed, subject to the usual provisions as to superannuation, &c. Mr. Roscoe was, till his appointment, in the employ of the Liverpool Electric Supply Company, Limited, a company which has probably a larger output than that of any other using the simple parallel system of distribution at low pressure.

Smoking Concerts.—A most successful Smoking Concert was given by the staff of the General Electric Company on Friday evening, February 20th, at the Mason's Hall Tavern, Basinghall Street, Mr. Max Binswanger, in the chair. An excellent company assembled, and the variety programme, consisting of comic and sentimental songs, violin solos, and a comic sketch, entitled "Black Justice," appeared to give great satisfaction, judging from the frequent encores. After an enjoyable evening, the concert closed with the usual vote of thanks to the chairman, which was passed with musical honours.

The cricket club of the Electric Construction Corporation, formerly known as the E.P.S.C.C., held their annual smoking concert at Limehouse Town Hall on Friday last, the 20th inst.; the managing director, Mr. Joseph Ebb Smith, presiding. During the evening the best batsman of the season, Mr. A. Shaw, was presented with a handsome bat, and the best bowler, Mr. I. A. Munroe, with a travelling bag. A most cheerful evening was spent by all present.

Award.—The Endolithic Ivory Company, Limited, were awarded the only prize medal and diploma for address, tablets, and switchboard labels at the exhibition lately held in Edinburgh.

Electric Lighting at Croydon.—The question of overhead wires was discussed at a recent meeting of the Croydon County Council, and the Town Clerk reported that the Board of Trade proposed to insert in the electric lighting provisional order a clause to the effect that overhead wires shall not be erected without the consent of the Board of Trade. The General Purposes Committee, in their report, thought that as no such prohibition was contained in any provisional order granted to a local authority last session, and although it is probable that in all the principal streets, and perhaps throughout the borough, the council would think it desirable to have underground wires, yet they (the committee) considered the restriction undesirable, and appointed a deputation to wait upon the Board of Trade, and remonstrate against its insertion. In the course of a discussion, the opinion was expressed that it would be unwise to try and remove the restriction the Board of Trade had imposed. The introduction of overhead wire was viewed with apprehension, but the report was adopted on the ground that the committee should be left unfettered.

Presentation at Widnes.—The workmen of the Liverpool Silver and Copper Company, Limited, Widnes, last week presented their manager, Mr. William Gibbings, with a handsome marble timepiece and bronze statuettes to match, in commemoration of his marriage, which took place on the 5th instant. In acknowledging the gift, Mr. Gibbings said that where the relations between capital and labour were friendly, both were benefited. The directors would themselves, he had no doubt, be gratified with what had taken place, and take it as indicative of the good relations which existed all round. The proceedings concluded with a vote of thanks to the chairman. We understand that this company are very large makers of high conductivity copper for electrical purposes, and that their brands have a high reputation in the market.

To the Best of his Knowledge.—A correspondent who objects to finding leaflets of the celebrated Harness's goods in the folds of his copy of the *Strand Magazine*, wrote to the editor of *Tit-Bits*, both journals, we understand, belonging to the same proprietor. To his complaint he received the following reply :—"Dear Sir,—I am duly in receipt of your letter, and desire to thank you for drawing my attention to the matter you refer to. To the best of my knowledge, the advertiser you name is quite respectable, and his appliances have, I am informed, done an immense amount of good.—Yours very truly, THE EDITOR."

Personal.—Mr. Rankin Kennedy has opened newly built and specially fitted works at Carntyne, Glasgow, for the manufacture of a number of recently patented inventions in connection with electrical distribution plants and alternating motors.

City Commission of Sewers.—The Streets Committee laid before the Commission a letter from the Board of Trade intimating that they were satisfied that the Electrical Engineering Companies were in a position to discharge the duties and obligations imposed upon them by the City of London (Brush) Electric Lighting Order, 1890. Mr. Morton, M.P., asked whether the Commission were dealing with the two companies with whom they had contracted in regard to the electric lighting of the City or with the company of which the Lord Mayor was chairman. The chairman said that, as he understood the matter, they had nothing whatever to do with the latter company. After the transaction of some other business, the court adjourned.

Electricity as a Life Preserver.—Despite the fact that the electric light has been the reputed cause of many recent fires, it enabled the inmates of a country mansion in Buckingham to leave a burning building in comparative safety. Maids-Moreton Lodge, the residence of the Baroness Kinross, was discovered early in the morning of Sunday to be on fire, the inhabitants were abed at the time, and it seemed that the conflagration was likely to be attended with fatal results, when the electric light, which had been lately installed, was turned on, and the inevitable confusion usually attendant upon fires, was prevented.

The Cost of Electric Incandescent Lighting.—The lighting engineer to the Vestry of the parish of St. Mary Abbotts, Kensington, has reported to the Special Purposes Committee the result of some interesting experiments in comparing the illumination of Kensington Town Hall by gas and by incandescent lamps. The conclusion he arrives at is that, light for light, electricity at 8d. per unit costs nearly three times as much as gas, which in his district is 2s. 9d. per 1,000 cubic feet. This bears out what is now generally conceded that electrical energy at 6d., 7d., 8d., 9d., 10d., &c., per unit, may be regarded as equivalent to gas at 6s., 7s., 8s., 9s., 10s., and so on, per 1,000.

The Royal Society.—The Croonian Lecture was to be delivered last night by Mr. F. Gotch and Prof. Victor Horsley, F.R.S., "On the Mammalian Nervous System, its Functions and their Localisation determined by an Electrical Method."

Obituary.—Friends of Mr. W. T. Glover, of Manchester, the well-known cable manufacturer, will be extremely sorry to learn of the loss he has sustained by the death of his wife. This lady was well-known and highly-esteemed by many friends of her husband in the electrical profession. Her early death had been for some time forseen, but the end came rather suddenly, and the deceased lady passed away on the 23rd inst., at the early age of thirty-six, leaving behind a family of three children.

The World's Columbian Exposition.—Mr. John P. Barrett, city electrician of Chicago, has been appointed electrician to the forthcoming exhibition.

Electricity in the Navy.—The *Royal Sovereign*, which was launched by Her Majesty at Portsmouth yesterday, will be lighted throughout by electricity ; 600 lamps are to be fitted, and four search lights of 25,000 candle-power.

The Proposed Pacific Cable.—A contemporary's telegram states that the vote of the United States Senate, appropriating the sum of $3,000,000 as a subsidy for the Hawaiian cable, is strongly opposed in the House of Representatives.

The Electrical Standards Committee.—The following members of the Electrical Standards Committee were present at the meeting held at the Board of Trade on Friday last :—Mr. Courtenay Boyle, Major Cardew, Mr. Graves, Mr. Preece, Sir William Thomson, Lord Rayleigh, Prof. G. Carey Foster, Mr. R. F. Glazebrook, Dr. John Hopkinson, and Prof. Ayrton. Mr. R. E. Crompton, Dr. Fleming, and Dr. Alexander Muirhead attended and gave evidence.

Musical Telegraph Clerks.—The St. Cecilia Orchestral Society, which is a musical association formed by the staff of the Central Telegraph Department, gave a grand vocal and orchestral concert on Friday last at the Foresters' Hall, Clerkenwell Road. The room was well filled, and the whole performance gave satisfactory evidence that the society has attained a high state of efficiency. The singing of Mr. Alex. McEwan, and the violin playing of Mr. Bernhard Carrodus met with special appreciation, but every item of the programme was well received and applauded. Mr. Arthur Crudge was the conductor, and he is to be complimented upon the high degree of efficiency exhibited by the forces under his baton.

The City Railway and the Spurgeon Orphanage.—There is a good deal of misapprehension with regard to the question at issue between the trustees of Mr. Spurgeon's Orphanage and the directors of the City Railway. The facts are as follows :—The Orphanage Homes for Boys and Girls, founded by Mr. Spurgeon, accommodating about 500 children, lie back some distance from the Clapham Road, and form a quadrangle enclosing four acres of land. Until now the institution has been a kind of *rus in urbe*, but the construction of the railway is looked upon as a calamity. The railway company has acquired land immediately in the rear of the orphanage, and the trouble complained of is the vibration caused by the engines generating the power, which are situate about ten feet from the wall. It is said by the managers of the orphanage that the nuisance is intolerable, and one portion of the establishment has been vacated in consequence. Although the railway directors have endeavoured to mitigate the evil, it seems highly probable that the matter will be taken into the law courts.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Grange Syndicate, Limited.—The statutory return of this company, made up to the 15th December, was filed 30th December. The nominal capital is £2,000, in £5 shares. 229 shares are taken up, upon 207 of which the full amount has been called, upon 20 £3 per share, and upon the remaining two, £4 per share has been called. The calls paid amount to £808, and unpaid to £295. Offices, 3, Tokenhouse Buildings, Tokenhouse Yard, Bank, E.C.

Sheffield Telephone Exchange and Electric Light Company, Limited.—The statutory return of this com-

pany, made up to the 26th ult., was filed 3rd inst. The nominal capital is £100,000 divided into 8,000 ordinary and 2,000 preference shares of £10 each; 1,007 preference and 4,000 ordinary shares are taken up, upon all of the preference shares the full amount has been called, and upon all of the ordinary shares £8 per share has been called. The calls paid amount to £9,840, considered as paid to £32,000, and unpaid to £230. Offices, Commercial Street, Sheffield.

Elmore's Austro-Hungarian Patent Copper-Depositing Company, Limited.—The statutory return of this company, made up to the 6th inst., was filed on the 11th inst. The nominal capital is £200,000 in £2 shares; 50,000 shares are taken up, upon all of which the full amount has been called. The calls paid amount to £87,205 15s., and unpaid to £12,794 5s. Offices, 20, Bucklersbury, E.C.

Elmore's French Patent Copper Depositing Company.—The statutory return of this company, made up to the 23rd ult., was filed 30th ult. The nominal capital is £200,000, in £2 shares; 66,750 shares are taken up, upon all of which the full amount has been called. The calls paid amount to £123,064, and unpaid to £10,436. The registered office of the company is changed to 64, Cannon Street, E.C.

CITY NOTES.

The St. James's and Pall Mall Electric Light Company, Limited.

THE report of the directors of this company is one of the most hopeful of any of those issued as yet by any electric light company. It is published below, with the accounts and balance sheet, and can be, therefore, readily examined by our readers. The profit available for dividends and interest on debentures, &c., is put down at £4,978, or close upon £5,000; but about £1,000 for directors' remuneration, and for salaries of secretary, engineers, clerks, &c., has been charged to capital instead of revenue account, because, as the directors state, the station has been at work for three months only in 1890. A second station has now to be undertaken, and assuming that similar results are realised during a complete year on both installations, it seems quite probable that the company may in the near future pay a high rate of dividend on its ordinary shares, after paying the 7 per cent. dividend on the preference shares, but it must not be forgotten that after 7 per cent. is paid on the ordinary shares, the founders' shares will divide the remaining profits equally with them. Doubtless the stoppage of the supply of electricity by the London Electric Supply Company has helped very materially the rapid development of the company, whose position we are now considering; at the same time it is generally held that the districts of the latter are, for electric lighting purposes, the very finest in the metropolis, and the future of the Company, if the same able management is continued, should, therefore, be well assured.

The St. James's and Pall Mall Electric Light Company, Limited.

THE directors in submitting their annual report for 1890, with accounts as certified by the company's auditors, congratulate the shareholders on the satisfactory progress made by the company during the past year.

At the commencement of the period under review, the number of lights connected amounted to the equivalent of about 4,460 8-candle-power lamps. This number gradually increased up to the 30th September, when the number of lamps connected amounted to about 12,150. In the last quarter of the year remarkable progress was made, and on the 31st December the lamps connected amounted to about 26,500, and this total has since been increased to about 30,000.

On the 23rd July last, a prospectus was issued inviting subscriptions at par for 3,670 ordinary shares. All these shares have been taken up, the bulk of them being subscribed for by the directors and their friends, the shareholders subscribing for a very small number.

On the 9th of January the balance of the original issue of shares, viz., 980, was allotted. These subscriptions have enabled the board practically to complete the existing station, which is now in every way working satisfactorily.

Of the £50,000 debentures which, as will be seen from the accounts, were outstanding on the 31st December, £43,000 have since been converted into ordinary shares under the powers contained in the debentures. On the conversion of the balance of £7,000 of the debentures, the capital account of the company would stand as follows:—

19,980 ordinary shares of £5 ...	£99,900	0 0
100 founders' „ £1 ...	100	0 0
Making a total of ...	£100,000	0 0

The conversion of these debentures places the company in a position to at once raise moneys for the purposes of the Northern station, which the company has to erect to satisfy the requirements of the district covered by the provisional order granted by the Board of Trade, and approved by Parliament during its last session.

The question of the amount of damages payable by the contractors for delay was referred by consent to the arbitration of Mr. J. Fletcher Moulton, Q.C., who awarded the sum of £1,806 11s. 6d. to the company for loss of income. The directors being of opinion that this sum represents the equivalent of depreciation up to the 31st December, 1890 (a large part of the machinery having been in work for but a short period), have written this amount off capital expenditure.

By reference to paragraph 2 of this report, it will be seen that the station has practically been at work for three months only in 1890, and that the dividend has been earned during that period. The directors have, therefore, after consultation with the company's auditors, charged £963 3s. 1d., being one moiety of directors' fees and management salaries for the year, to capital expenditure. On Statement III. it will be seen that the account of capital is charged with £65,981 11s. 9d., as expended to December 31st, 1889. The balance sheet at that date displays that this sum is made up of capital and general expenditure, from which is deducted a small sum received for current supplied, &c.

During the first six months of the year the company's revenue showed a debit of £183 7s. 11d. During the last six months the profit amounted to £5,161 8s. 8d., which, after deduction of the debit referred to, leaves a balance of £4,978 0s. 9d. to be dealt with. Of this sum £2,412 8s. has been provided for payment of interest, and out of the balance of £2,565 12s. 9d. the directors recommend a dividend of 5s. per share, free of income tax, on the 9,000 ordinary shares in existence on the 31st December, 1890, absorbing £2,250, leaving a balance of £315 12s. 9d. to carry forward.

The experience gained since September has satisfied the directors that the shareholders possess a very valuable property, which will yield a large steadily increasing income on their investment.

The directors regret the loss of their esteemed colleague, Mr. James Hemmerde, who died in the autumn of last year; they have, under Article 84, appointed Mr. Egerton H. Clarke to a seat on the board in his stead.

Two of the directors, namely, Mr. Eustace J. A. Balfour, the chairman, and Mr. Latimer Clark, F.R.S., retire under Clause 79 of the articles of association, and, being eligible, offer themselves for re-election.

The auditors, Messrs. Deloitte, Dever, Griffiths & Co., also retire, and being eligible, offer themselves for re-election.

Referring to the notice of the extraordinary general meeting, should the shareholders adopt the suggestion of the directors to increase the capital of the company by the creation of 7 per cent. preference shares, it is the intention of the directors to offer 10,000 of such shares to shareholders now on the register in the proportion of one preference share to every two ordinary shares. It being necessary to alter the articles of association to entitle this company's shares to a quotation on the Stock Exchange, the directors have taken the opportunity to remodel them.

No. III.—CAPITAL ACCOUNT *for the year ending 31st December*, 1890.

DR.	£ s. d.	£ s. d.
To expenditure to 31st December, 1889, per last account, including preliminary expenses, see paragraph of directors' report		65,981 11 9
„ buildings and paving	124 18 4	
„ machinery and plant	10,876 8 6	
„ accumulators	1,543 10 5	
„ mains, including cost of laying ...	8,171 8 11	
„ meters fixed on installations... ...	1,322 11 0	
„ switches do. do.	509 19 6	
„ stores and labour used on do. ...	1,172 19 7	
„ electrical instruments	166 13 1	
„ cost of licence, provisional order, &c.	359 10 1	
„ sinking artesian well	424 2 6	
„ proportion of directors' fees and management salaries, chargeable to capital expenditure in 1890, see paragraph 8 of directors' report...	963 3 1	
„ office and other furniture and fittings, 1889 ... £247 4 1		
„ Ditto, ditto, 1890 ... 262 17 4		
	510 1 5	
	26,145 6 5	
„ less £1,806 11s. 6d. recovered from the contractors under an award of Mr. Moulton, Q.C., as being loss of revenue for delay (this amount represents the equivalent of depreciation, see directors' report, paragraph 7)	1,806 11 6	
		24,338 14 11
		90,320 6 8
Balance of capital account		4,659 13 4
		£94,980 0 0

Cr.	£	s.	d.	£	s.	d.
By ordinary shares, 9,000 of £5 each ...	45,000	0	0			
Less calls in arrear (paid in 1891) ...	120	0	0			
				44,880	0	0
„ founder's shares, 100 of £1 each				100	0	0
„ 6 per cent. mortgage debentures				50,000	0	0
				£94,980	0	0

No. IV.—REVENUE ACCOUNT *for the year ending December 31st, 1890*

A.—*To Generation and Distribution of Electricity.*

Dr.	£	s.	d.	£	s.	d.
To coals and other fuel, including dues, carriage, &c.	2,617	0	4			
„ oil, waste, and engine-room stores ...	591	19	8			
„ salaries of engineers and officers ...	328	6	8			
„ wages at generating and distributing station	1,624	0	7			
„ repairs and maintenance, as follows:—						
1. Buildings ... £16 2 5						
2. Engine and boiler . 47 17 0						
3. Accumulators .. 0 5 0						
4. Lamps (at station) 38 7 11						
	102	12	4			
„ miscellaneous expenses	30	7	10			
				5,294	7	5

B.—*To Rent, Rates, and Taxes.*

To rents payable	227	15	0			
„ rates and taxes	294	12	11			
				522	7	11

C.—*To Proportion of Management Expenses.*

To directors' remuneration (balance after charging £500 to capital) ...	500	0	0			
„ salaries of secretary, engineer, clerks, &c. (balance after charging £463 3s. 1d. to capital)	497	6	5			
„ stationery, printing and advertising .	291	7	7			
„ general establishment charges ...	171	10	1			
„ auditors	26	5	0			
				1,486	9	1

D.—*Law and Parliamentary Charges.*

To law expenses				214	9	2

E.—*To Special Charges.*

To insurance				30	3	7
Total expenditure				7,547	17	2
To balance carried to net revenue account				4,978	0	9
				£12,525	17	11

Cr.	£	s.	d.
By sale of current	12,282	4	7
„ rental of meters on consumers' premises	126	14	2
„ rents receivable	100	0	0
„ transfer fees	4	9	6
„ discounts on purchases	12	9	8
	£12,525	17	11

No. V.—NET REVENUE ACCOUNT *for the year ending Dec. 31st, 1890*

Dr.	£	s.	d.	£	s.	d.
To interest on debentures	2,363	11	7			
interest on temporary loans and bills payable	48	16	5			
				2,412	8	0
„ balance, being net profits applicable to dividends on shares				2,565	12	9
				£4,978	0	9

Cr.	£	s.	d.
By balance brought from revenue account (No. IV.) ...	4,978	0	9
	£4,978	0	9

No. VI.—GENERAL BALANCE SHEET, *December 31st, 1890.*

Dr.	£	s.	d.
To capital account—			
Amount received as per account No. III. ...	94,980	0	0
„ sundry tradesmen and others, due on construction of plant and machinery, fuel, stores, &c. ...	4,744	4	0
„ sundry creditors on open accounts	1,342	9	10
„ bills payable	1,746	1	0
„ net revenue account—			
Balance at credit thereof	2,565	12	9
	£105,378	7	7

Cr.	£	s.	d.	£	s.	d.
By capital account—						
Amount expended for works, as per Account No. III.				90,320	6	8
„ stores on hand—						
Coal	427	10	0			
Oil, waste, &c.	47	10	2			
Meters	172	6	0			
Switches	29	12	0			
General	1,151	6	8			
				1,828	4	10
„ sundry debtors for current supplied .				6,576	1	0
„ other debtors				79	4	8
„ cash at bankers (Lloyd's Bank, Limited)	6,553	3	8			
„ cash in hand	21	6	9			
				6,574	10	5
				£105,378	7	7

EUSTACE J. BALFOUR, *Chairman.*

Audited and approved,

DELOITTE, DRVER, GRIFFITHS & CO.,

Chartered Accountants, Auditors,

4, Lothbury, E.C., *February 17th*, 1891.

City and South London Railway.

THE thirteenth half-yearly meeting of the City and South London Railway Company was held on Tuesday at Winchester House, Mr. C. G. MOTT (Chairman) presiding.

The CHAIRMAN, at the outset of his remarks, expressed pleasure at meeting the shareholders with a completed and working line. They all knew that in new undertakings of that kind, where so much was new and so little could be guided by the experiences of the past, that there always existed a feeling of uncertainty that, however much they might have studied the question, however much care might have been taken in the execution of the works, there might yet be something that had been overlooked, that after all might render all their labours and care of no effect. In an undertaking so new in all its parts as their line was, they were especially open to such a possibility. But he was thankful to feel that they had had in the experience of their line so far the satisfaction of knowing that no serious defect in their calculations had been apparent. He considered that for a new line—new in construction, new in working, and new in all its arrangements—it was an unqualified success. Their motive power had proved a very marked success. They had had no serious drawbacks. Since the line was opened, two or three days before Christmas, they had carried 900,000 passengers in perfect safety, and they had run their engines 600,000 miles over the line. In money they had received about £7,500, equal to 15 passengers per train mile. In a metropolitan line like that they expected to have a very large number of passengers per train mile. It was very different from what it was on a great system like the Great Western or North-Western, where the number per train mile was only three or three and a-half. Considering their line was so new, that they had never advertised it in any way, and had only dealt with the traffic which had voluntarily come to them, and which they had been compelled to deal with, he thought that their traffic had been on the whole very satisfactory. As to the expenses of the line, he did not feel justified in making any definite statement upon that subject. At the opening of a line of that sort they naturally had to go to extra expenditure in order to make security doubly sure, but as the working of the line settled down, they were from week to week reducing the expenses. They had had so short an experience of working the line that it would be utterly wrong for him to give them even an approximate statement of the working expenses. But he might say this—that, so far as he had carefully investigated the matter, he felt quite sure in saying that when they settled down properly they would find that the cost of working the line by electricity would be decidedly cheaper than working it by steam. The actual receipts per train mile had been half-a-crown. In working the line they had discovered that they would be able to work it more economically and with greater economy if they had additional sidings underground, and therefore arrangements were now in progress for the construction of additional sidings at the Stockwell terminus. Referring to the question of extending the line to Islington, he said that for his own part, and he believed his feeling was shared by his colleagues, he should have been glad to have avoided extensions of any kind for the present. They had got, as the shareholders knew, powers for constructing the Clapham extension, but they did not intend to proceed for the present with that line. They found, however, in working the line now open, that there were certain things which made it desirable that the line should be extended in the direction which they now proposed to ask Parliament to grant them powers for. They had certain difficulties to deal with in regard to their City traffic at the present moment which the proposed extension would help them to overcome. They wanted the middle part of the day, as well as the early morning and the evening, filled up with traffic for which they had abundant accommodation, and for which the expenses were going on as matters now stood. The board did not think that that part of the day he had referred to could be filled up entirely by the traffic of the district the line now served. It

would have to be filled up by traffic drawn from the larger and still more populous area which they proposed, by the extension to Islington, to bring upon the line. For the extension they had chosen a district in which the traffic was enormous, and which, he felt satisfied, from their present knowledge, would be a very remunerative undertaking in itself. But in addition to that it would bring to the existing line exactly the sort of traffic in which they were deficient and would greatly improve the value of their property. Of course, in approving of the Bill asking for powers to carry out the extension, they were not approving of the construction of the works, for the execution of which the board would first of all have to get the shareholders' consent after Parliament had passed the Bill. In conclusion, he moved the adoption of the report.

Mr. A. HUBBARD seconded the resolution.

The CHAIRMAN, in reply to various suggestions, said it was a difficult matter to enlarge the station at King William Street. It could not be lengthened, because in front of it was the Monument, and they would not be allowed to go any nearer to that than they now were. Under the circumstances he was afraid that King William Street Station was not capable of being greatly improved. The position of this station was one of the reasons for the proposed extension. One of the difficulties connected with that station they now had to deal with was its surface approach. It was exceedingly bad. Every one going to or from the City had to pass over one of the worst crossings in the City of London, and undoubtedly that greatly damaged their traffic. In connection with the extension to Islington, they proposed to make the King William Street Station at that part of the street near Lombard Street, so that passengers would be able to go down that station into the present one.

After some remarks from Mr. BARRY, M.P., and other SHAREHOLDERS, the report and statement of accounts were adopted.

The adjourned extraordinary general meeting was then held.

The CHAIRMAN proposed "That the Bill now read, entitled 'A Bill to empower the City and South London Railway Company to make an underground railway to Islington, and for other purposes,' be approved subject to such alterations and variations as Parliament may think fit to make therein."

Mr. A. HUBBARD seconded the resolution.

In reply to several shareholders, the CHAIRMAN said that, considering the number of petitions which had been lodged against the Bill, it might cost the company £2,000 or £2,500 to obtain it. They could not be quite certain. If it were an unopposed Bill it might not cost more than £700 or £800. In the event of the extension being constructed, the King William Street platform of that line, and the King William Street platform of their present line would be connected by a footway similar to that at Baker Street. Replying to a question with regard to the estimated cost of the line, he said that the present line cost £250,000 a mile. The extension would be two miles in length, and so would cost £500,000 if constructed at the same cost per mile. In the City, however, they had to purchase expensive property. This would be subsequently resold and let, but they must have the necessary powers to purchase this in the first instance. The extension might perhaps cost less per mile than the present line. He did not think the company would have to issue preference shares. He believed their present shares would be at such a price before the proposed extension would be undertaken that they would not be required to do so.

The resolution was then put and carried with about half-a-dozen dissentients.

Mr. BROAD demanded a poll.

Mr. COURT, who had expressed himself as favourable to the extension, said he might save that gentleman the trouble of pressing for a poll by mentioning that he represented £80,000 of capital.

The CHAIRMAN stated that the Board held proxies for 195,000 shares in favour of the resolution against the 2,000 shares held by Mr. Broad.

Eventually Mr. Broad withdrew his demand for a poll.

On the proposition of the CHAIRMAN, seconded by Mr. W. ROBINSON, a resolution was agreed to empowering the directors, if they thought fit, to make the proposed extension from King William Street to Islington a separate undertaking, with separate capital, a separate proprietary, and separate borrowing powers.

The proceedings then terminated with a vote of thanks to the chairman.

Westminster Electric Supply Corporation, Limited.

IN submitting their report to the shareholders, the board are pleased to be able to state that the business of the corporation is proceeding in a satisfactory manner.

At the present time current is being supplied to the equivalent of about 12,000 lamps of 8 C.P.; formal applications have been signed for about 17,000 more, and numerous enquiries continue to be made for the supply of current.

The central station in Millbank Street is now finished, and has been running continuously day and night since November 13th, 1890. Current is being supplied from this station throughout the whole length of Victoria Street, in various parts of Pimlico, and also to the Houses of Parliament. The temporary station in Dacre Street is still supplying current to the western portion of the district as far as Belgrave Square and its neighbourhood.

The two other permanent central stations of the corporation, namely, those in Eccleston Place, S.W., and in Davies Street, W. have been greatly delayed by the severe frost, which practically rendered building operations impossible for two months. Great progress has, however, been made, and in both cases temporary buildings have been put up, covering a part of the engine and boiler room space, sufficient to allow of current being supplied while the building operations are being completed. Engines, dynamos and boilers are now in place at each station, and Prof. Kennedy reports that these will be at work in the course of next month.

The work of laying the mains, like that of building, was seriously hampered by the severe weather. Notwithstanding this, since the work was started in February, 1890, mains have been laid along about 16 miles of roadway, and these include a total length of about 75 miles of "ways," into which about 40 miles of copper have been drawn.

In consequence of the great and pressing demand for the supply of electric current, it has been necessary to proceed with greater rapidity than at first arranged with the laying of mains throughout the district. This has led to the calling up of the capital sooner than was anticipated, but will result in an earlier division of profit.

The board have applied to Parliament for powers to supply electricity in the northern part of the parish of St. Margaret, Westminster, which was not included in the original provisional order. Many petitions for the admission of the low tension system have been signed by residents in that district, and the decision of the Board of Trade is shortly expected. This area, comprising, among others, Bridge Street, Parliament Street, Great George Street, Queen Anne's Gate, and part of Whitehall, can be supplied from the existing station in Millbank Street, and consequently if obtained, will prove a valuable source of revenue.

To complete the works now in hand, and to provide for such new works as the directors may consider desirable, they propose to obtain the consent of the shareholders to the issue of the balance of the authorised share capital, £85,235, in 17,047 shares of £5 each.

CAPITAL ACCOUNT, 31st December, 1890.

DR.	£	s.	d.
To lands, including law charges incidental to acquisition	16,916	19	2
„ buildings (part in course of erection)	19,758	4	7
„ plant and machinery ditto	26,845	8	0
„ mains, including cost of laying	41,300	5	5
„ meters and cost of calibrating	2,092	9	6
„ instruments	205	17	11
„ purchase of City of Westminster Electrical Syndicate	10,000	0	0
„ provisional orders, &c.	2,968	0	1
„ office furniture and fittings	521	8	11
Total expenditure	120,608	13	7
To balance of capital account	19,671	6	5
	£140,280	0	0

CR.	£	s.	d.
By ordinary shares of £5 (42,853) £3 paid	128,559	0	0
Less calls in arrear	269	0	0
	128,290	0	0
„ founders' shares of £5 (100)	500	0	0
	128,790	0	0
„ amount received in anticipation of calls ...	1,490	0	0
„ temporary loan	10,000	0	0
	£140,280	0	0

REVENUE ACCOUNT *from the 30th June, 1888, the date of the Incorporation of the Company, to the 31st December,* 1890.

A. *To Generation of Electricity.*

DR.	£	s.	d.
To coals, fuel, &c.	709	13	9
„ oil, waste, stores, and water	382	17	5
„ proportion of salaries of engineers	187	10	0
„ wages	561	6	4
„ repairs and maintenance	51	1	11
	1,892	9	5

B. *Rents, Rates, Taxes, &c.*

„ proportion of rents	228	0	0	
„ „ taxes	6	8	0	
				234 8 0

C. *Management Expenses.*

„ proportion of salaries of officers ...	100	0	0	
„ stationary and office expenses ...	25	0	0	
				125 0 0

D. *Insurance, &c.*

„ insurance of buildings and machinery				15 11 0
				£2,267 8 5

Cr.	£	s.	d.
By sale of current by meter at 8d. per Board of Trade unit 1,781 11 7			
„ sale of current by contract 317 2 6			
	2,098	14	1
„ rent of meters, &c.	44	0	8
„ transfer fees	15	2	0
	2,157	16	9
„ stores on hand—			
oil, waste, &c. 10 15 9			
coals 36 0 0			
	46	15	9
	2,204	12	6
„ balance carried to net revenue	62	15	11
	£2,267	8	5

NET REVENUE ACCOUNT, *December 31st*, 1890.

Dr.	£	s.	d.
To interest on temporary loans	55	4	4
„ balance from revenue account	62	15	11
„ „ carried to balance sheet	714	12	6
	£832	12	9

Cr.	£	s.	d.
By interest on deposits, &c.	703	14	6
„ rents of freehold property	128	18	3
	£832	12	9

GENERAL BALANCE SHEET, *December 31st*, 1890.

Dr.	£	s.	d.
To capital account	140,280	0	0
„ sundry creditors	3,314	4	0
Net revenue account—			
Balance at credit	714	12	6
	£144,308	16	6

Cr.	£	s.	d.	£	s.	d.
By capital account				120,608	13	7
„ stores on hand—						
Coals	36	0	0			
Oil, waste, &c.	10	15	9			
				46	15	9
„ sundry debtors on account of contracts				10,500	0	0
„ „ „ for current supplied				1,097	14	0
„ other „				211	6	11
„ preliminary expenses, including commission to brokers on issue of capital				5,285	7	7
„ cash at bankers' (Messrs. Barclay, Ransom and Co.)				1,953	16	0
Deposits with vestries, &c.				648	0	0
Expenditure during year but applicable to future business				3,957	2	8
				£144,308	16	6

We have examined the above statements and balance sheet with the books and accounts of the corporation, and certify the same to be correct.

(Signed) COOPER BROTHERS & Co.,
Chartered Accountants, Auditors.

London, *February 11th*, 1891.

The fourth ordinary general meeting was held at the offices in Victoria Street on Wednesday last.

The CHAIRMAN (Lord Suffield) spoke as follows:—Gentlemen—The report which has been sent to each shareholder will have already made you acquainted with the fact that the business of the corporation is going on satisfactorily. Since our last general meeting on the 5th of November, the Millbank Street central supply station has been completed, and current has been supplied therefrom continuously, day and night, in a most satisfactory manner. It frequently occurs that when a station is first opened, some unexpected flaw, either in the machinery or in the mains, is brought to light, causing a serious breakdown, but I am happy to say that this has not been our experience. Some slight irregularities in the light did occur for a few days, but this was before we got on to the batteries. Since then the light has been perfectly steady and satisfactory, notwithstanding the unusual demand throughout the whole of several days in consequence of fogs. You will hardly need to be told that fogs, however unpleasant they may be from a sanitary point of view, are, from an electrical point of view, a very different matter. We find that our heaviest loads come in during fogs, so that to us they are a source of profit instead of loss. I am glad to be able to inform you that since taking over the Millbank Street station from the builders, we find that we have every reason to be satisfied with the work, and that the building is in every way suitable to our requirements, so much so, that when Sir William Thomson visited the station, he not only expressed himself as perfectly satisfied, but declared it to be one of the best he had ever seen. We have now sufficient plant and machinery erected there to supply all the lights likely to be required for the next six months, and as the demand increases so shall we increase our machinery. I may here point out a great advantage which the Westminster district possesses over many others, which is that within it are a large number of offices, in addition to private houses and shops, and that these offices, requiring as they do to be lighted in the winter months through many hours each day before the chief part of the lighting of the private houses comes on, enables us to use our Millbank Street Station to great advantage. We are at present supplying from the Millbank Street Station some 9,000 lamps of 8 candle-power each. The cost of running at that station is now about £60 per week. This includes the cost of coal, water, stores, salaries and wages. To this has to be added £90 per week for maintenance, depreciation of machinery and mains, establishment charges, rent, and sinking fund on buildings, &c., making in all £150 per week. At the beginning of the month of January the income per week for current supplied had already reached £150, which has now increased to £200, so that even in this early stage a profit is already being made. Of course, as the days lengthen, the same ratio will not be kept up, nevertheless, it is to be noted that though the days have been lengthening of late, and the demand for current has, in the case of other companies which have been longer established, been falling off in consequence, our receipts have augmented. This is, of course, attributable to the increased number of lights which are daily being installed in the district, or at any rate mainly so. The temporary station in Dacre Street, at the back of these offices, which is supplying the remainder of the lamps on circuit, has been of great service to us in enabling us to supply current to the western portion of our district while the station at Eccleston Place was being built. In a few days the Eccleston Place Station will be delivering current, and the temporary station will then be closed as soon as possible. The directors have visited the Eccleston Place Station as well as the other new station in Davies Street, and were very much gratified with the progress made. It has been very much delayed by frost, but is now progressing in a most satisfactory manner, and will, as I have just said, be able to deliver current in a few days. At our Davies Street Station great progress has been made, and from there we expect to be supplying current by the end of next month. You will observe, by looking at the map on the walls, with what rapid strides the work of laying the mains has proceeded since you were last called together. There were then about 11 miles laid. To-day, notwithstanding interruptions, there are about 18 miles completed. This includes the principal streets throughout the district in which there is the greatest demand. The others will be completed in the order in which the demand arises. I should mention that our consumption of coal already bears favourable comparison with that of the most economical of the older established companies, and that when the condensing plant now on order is erected, which in the case of the Millbank Street Station will be in the course of the next two months, a still greater saving will be effected. Now, as to the question of capital and expenditure. You will see from the accounts sent with the report the expenditure under the different heads to the 31st December last. Owing to the demand for light caused by the stoppage for about two months or more of the supply of the only other company having powers in the same district as ourselves, it was considered desirable by the board to increase the amount of copper in the mains, especially in the Mayfair district, for which large numbers of applications have been received. This has largely increased the expenditure on mains, but, of course, will result in the earlier sharing of profits, as we shall be enabled to take on a much larger number of lights without delay. The board are pleased to say that, so far, the whole of the works, whether of buildings, mains, or plant, have been carried out well within the estimated cost, and that the total cost of the works to give enough current to supply the whole of our districts for some time to come will not exceed the amount of capital asked for in the original prospectus of the company, viz., 300,000. The amount actually subscribed was £214,765 in 42,953 shares of £5 each. To provide for the extra cost of laying mains, completing the present work in hand, and making provision for any extra work the board may consider it desirable to enter upon, they suggest to the shareholders that the directors be empowered to issue at their discretion all or any part of the balance of £85,235 in 17,047 shares of £5 each. They feel fully justified in asking them to increase their holdings, as there is no doubt of the future financial success of the undertaking. I would not make that statement, gentlemen, if I did not believe it to be absolutely true. The directors have also passed a resolution to issue if required £100,000 debentures at 5 per cent. interest, to run for a term of 10 years, but not to a greater extent than an amount of one-third of the share capital for the time being. I now beg to move the adoption of the report and accounts for the past year. If any shareholder has any question to ask, we shall be pleased to give him every information in our power. I will add that the calls on the shares have been very well paid up, and that only a small balance is left, which no doubt will be forthcoming. I now beg to move the adoption of the report and accounts for the past year. If any gentleman has any question to ask the directors will be very pleased to give any information that is in their power.

Mr. BOULNOIS seconded.

Mr. COOPER wished to know whether the last item on the credit side of the balance sheet, £3,957 "expenditure during year, but applicable to future business," was properly chargeable to capital. Should it not have taken its place in the revenue accounts?

Mr. ROGER WALLACE answered this question. In starting a company of this kind there was a vast amount of work to do, such as getting customers, travelling, and advertising, which would become remunerative in future years. It could not be placed at once to capital account, but would be written off the profits of future years.

Mr. MARK STEWART wished to know if any steps had been taken to secure the provisional order mentioned in the report, to obtain greater facilities in the northern part of St. Margaret's.

The CHAIRMAN: Yes; steps have been taken.

A question was asked regarding the proposed issue of debentures, and

The CHAIRMAN stated that there was no immediate necessity, but they took power to issue them in accordance with the custom of all other companies, and

Mr. BROWN-MARTIN, a director, explained further that it was better to issue debentures than new capital, because the new capital would share in the 7 per cent. dividend which they were certain to earn, whereas debentures could be got for 5 per cent.

Mr. G. R. SCOTT proposed the resolution giving the directors power to issue the debentures.

Mr. BOULNOIS seconded.

This was carried unanimously.

The auditors were then re-elected, and the usual vote of thanks concluded the meeting.

Manchester Edison-Swan Company, Limited.

AN extraordinary general meeting of the Manchester Edison-Swan Company, Limited, was held on the 23rd inst. at the Victoria Hotel for the purpose of considering the advisability of obtaining additional capital by the issue of debentures or otherwise. Mr. Vernon K. Armitage, chairman of the company, who presided, explained that the meeting was called in accordance with a promise made by the directors that the shareholders would be consulted before any scheme involving any considerable expenditure of money was entered upon. As he had informed the shareholders on a previous occasion, there had recently been a very marked diminution in the demand for small installations of the electric light, and the directors thought that in view of the large number of provisional orders which had been recently granted to local boards and corporations, it was desirable that they should have the ability, if they had the opportunity, to do such large work as the carrying out of such provisional orders would involve. Another reason why it was thought that it might be necessary to raise additional capital was this, that at present they were seriously handicapped in their competition with other companies by the circumstance that they were not manufacturers as well as installers. With facilities for making what they required, they would save much money which at present went to manufacturers of fittings, &c. The directors felt that if they were placed in a position to raise such money as they might consider necessary there was a future for the company, especially in a place like Manchester, where a provisional order for electric lighting had been obtained. By the articles of association the directors had full power to raise what money was required on debenture or by call, but, in accordance with the promise they had made, they desired to secure the assent of the shareholders before going forward. With reference to the general position of the company, he added that he thought there was not the smallest doubt that for the current year they would make 7 or 8 per cent. on the capital that had been called up. In reply to a question by Mr. F. B. Ross, the chairman stated that it was not yet known what amount it might be necessary to raise. That would depend altogether on the extent to which they were entrusted with orders. Their manufacturing work would be carried on in a small way to begin with. Some discussion followed, at the close of which, without any formal resolution being passed, it was left to the directors to obtain such additional capital as they considered necessary.

Telegraph Construction and Maintenance Company, Limited.

THE report of the directors, to be submitted to the members at the twenty-seventh ordinary meeting to be held on Tuesday, the 3rd day of March, 1891, states that the accounts for the year show a net profit of £113,681 4s. 8d., after charging the interest on the debentures. To this sum must be added £37,483 7s. 3d. brought forward from last year, making a total of £151,164 11s. 11d. From this amount is deducted the interim dividend of 5 per cent., paid July 15th, 1890, amounting to £22,410, leaving £128,754 11s. 11d. to be dealt with. Of this sum the directors propose to distribute a dividend of £1 16s. per share, absorbing £67,230, being at the rate of 15 per cent., and making, with the amount already paid, a total dividend for the year of £2 8s. per share, or 20 per cent., free of income tax, leaving £61,524 11s. 11d. to be carried forward to the next account.

During the past year the cable factories at East Greenwich and at Wharf Road have been fully occupied, and the increase in the general business at the latter works, mentioned in the last report, has been fully sustained; a length of over 9,000 miles of telegraph wire has been insulated for submarine cables and land lines during the year.

The company's ships have duplicated the Eastern Extension Telegraph Company's cable between New South Wales and New Zealand, have repaired and partially renewed the lines across Cook Strait, have partially renewed the Madras-Penang cable, and have quadruplicated the Eastern Telegraph Company's line down the Red Sea. A cable has also been laid between the north-east coast of England and Sweden for the Great Northern Telegraph Company, and repairs have been effected in the German Government cable between Greetsiel and Valentia.

The factories at East Greenwich and Wharf Road, and the company's steamships are in efficient working condition.

The retiring directors are Sir George Elliot, Bart., and M. Philip Rawson, who, being eligible, offer themselves for re-election.

The meeting will have to appoint auditors for the ensuing year. Mr. John Gane (of the firm of Messrs. Gane, Jackson and Jefferys), and Mr. Patrick A. Glegg (of the firm of Messrs. Welton, Jones & Co.), who retire, offer themselves for re-election.

Swan United Electric Company.

IN connection with the Swan United Electric Light Company, Limited, says the *Citizen*, a most interesting *resumé* of its financial history and prospects has been issued. It will be remembered that it was formed in 1882 with a paid up capital of £299,125. The following are the leading features:—

Year.	£5 shares of which paid.	Market price.	Paid up capital.	Dividends paid.	Amount in reserve invested.
	£ s.	£ s. d.	£	£	£
1883	2 10	2 0 0	299,125	—	—
1884	3 0	nom. 2 6	337,904	—	15,000
1885	3 10	" 2 6	376,259	—	19,420
1886	3 10	1 5 0	377,983	—	9,403
1887	3 10	1 10 0	375,069	—	29,403
1888	3 10	2 5 0	375,071	—	27,107
1889	3 10	3 to 6¼	375,071	6 p.c.	34,125
1890	3 10	4½ to 5½	375,071	10 p.c.	34,125
Estimate for 1891	3 10	Present price 4¾	375,071	20 p.c.	34,125

The company have a monopoly of the special light, and are getting the advantages which follow the rapid adopting of electricity for illuminating purposes. The executive are engaged in making provisions for the prospective expiry of their patent rights in 1897, both by consolidating the goodwill of their business, and by building up a reserve fund. The Swan United are certainly paying a handsome dividend, and what is better, there is every probability of the present rate of 20 per cent. being maintained.

The Liverpool Electric Supply Company, Limited.

A LARGELY attended annual meeting of the shareholders of the Liverpool Electric Supply Company, Limited, was held on Tuesday at the Law Association Rooms, Cook Street, Mr. Arthur Hill Holme, C.C., chairman of directors, presiding. In their eighth annual statement of accounts, the directors reported that the amount of net profit available for dividend was £4,878 9s. 6d., and out of this sum they recommended a dividend of 3½ per cent., which would absorb £4,074. The expenditure on capital account during the year had been £54,019. The number of lamps supplied from the company's stations on January 1st, 1890, was 6,700, and on January 1st of this year 11,750. It was anticipated that during the present year there would be still greater progress in this direction, with corresponding advantage as regarded profits. The directors had applied for Parliamentary powers to extend the present area of supply to London Road, Prince's Road, Prince's Park, and Sefton Park. In moving the adoption of the report and statement of accounts, he remarked that the company had made a considerable addition to their business during the past year. They had increased their number of fixed lamps from 6,700 to 13,074, although they had engines of sufficient power to supply 25,000 lamps. The directors had written off a sum of 3 per cent. for depreciation on all underground mains laid since the commencement of the company, including those which were not yet in use. The necessity of making a call upon the shareholders would probably not occur before January next, and then the call, it was anticipated, would not exceed 10s. per share.

The retiring directors and auditors were re-elected, and the meeting was brought to a close.

Taunton Electric Light Company.—The report of the directors of this company, which is to be presented at the fourth annual meeting for the first time since the company has been formed, does not recommend the payment of a dividend. The statement of accounts shows a deficiency of about £430 on the year's working. During the year the capital of the company has been increased, and extraordinary expenditure incurred in connection with the new depôt. The directors, however, anticipate that the working will prove remunerative in the future.

The Brush Electrical Engineering Company.—This company has issued warrants for an interim dividend on the preference shares for the half-year ended the 31st December last at the rate of 6 per cent. per annum.

The Western Counties and South Wales Telephone Company, Limited.—Warrants were posted on Monday last for the dividend upon the preference shares at the rate of 6 per cent. per annum for the half-year ending 31st December last.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The traffic receipts for the week ended February 21st, amounted to £718; aggregate receipts for half-year to date, £5,484.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending February 20th, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Company, were £4,928.

SHARE LIST OF ELECTRICAL COMPANIES.

Present Amount Issued.	Name.	Stock or Share.	Closing Quotation. (February 19).	Closing Quotatiion. (Feb. 26).	Business done during week ending February 26, 1891. Highest.	Lowest
250,000*l*	African Direct Telegraph, Ltd., 4 p. c., Deb. Regd. and to Bearer	100	99 —102	99 —102	99¾	...
1,381,380*l*	Anglo-American Telegraph, Limited	Stock	47½— 48½	47 — 48	48½	47⅝
2,809,310*l*	Do. do. 6 p. c. Preferred	Stock	84½— 85½xd	84 — 85	85½	84⅜
2,809,310*l*	Do. do. Deferred	Stock	12 — 12½	11½— 12	...	...
130,000	Brazilian Submarine Telegraph, Limited	10	11¾— 12¼	11¾— 12¼	12	...
84,500*l*	Do. do. 5 p. c. Bonds	100	100 —103	100 —103	...	...
75,000*l*	Do. do. 5 p. c., 2nd Series, repayable in June, 1906 ...	100	103 —107	103 —107	...	...
63,416	Brush Electric Engineering Ordinary, Nos. 1 to 63,416	3	2⅜— 2⅝	2⅛— 2⅜	2⅜	2⅛
63,416	Do. do. Non cum. Preference, Nos. 1 to 63,416	2	1½— 2	1½— 2 xd	1⅝	1¾
$7,216,000	Commercial Cable, Capital Stock	$100	107 —109	107 —109	108¼	108½
224,850	Consolidated Telephone Construction and Maintenance, Limited ...	14/-	7/16— 9/16	7/16— 9/16	...	...
20,000	Crompton & Co., Ltd, 7 p. c. Preference Shares, Nos. 1 to 20,000	Stock	5 — 5½	5 — 5½	...	...
16,000	Cuba Telegraph, Limited	10	10½— 11½xd	10½— 11½	11¼	11
6,000	Do. do. 10 p. c. Preference	10	16 — 17 xd	16 — 17	...	...
12,931	Direct Spanish Telegraph, Limited, ... (£4 only paid)	5	3¾— 4¼	3¾— 4¼	...	...
6,000	Do. do. 10 p. c. Preference	5	9 — 10	9 — 10	...	...
60,710	Direct United States Cable, Limited, 1877	20	10⅛— 10⅜	10⅛— 10⅜	10 3/16	10⅛
400,000	Eastern Telegraph, Limited, Nos. 1 to 400,000	10	14⅛— 14⅜	14 — 14¼	14⅜	14 1/16
70,000	Do. 6 p. c. Preference	10	15 — 15½	15 — 15½	15	...
200,000*l*	Do. 5 p. c. Debs. (1879 issue), repay. August, 1899	100	107 —110	107 —110	109¼	...
1,200,000*l*	Do. 4 p. c. Mortgage Debenture Stock	Stock	107 —110	107 —110	108¾	108½
250,000	Eastern Extension, Australasia and China Telegraph, Limited ...	10	14¾— 15¼	14¾— 15¼	15⅛	14 13/16
91,800*l*	Do. 5 p. c. (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	103 —106	103 —106	104	...
325,200*l*	Do. do. Bearer Nos. 1050—3,975 and 4,327—6,400 ...	100	103 —106	103 —106	...	...
320,000	Do. 4 p. c. Debenture Stock	Stock	104 —107	... ...	...	...
145,300*l*	Eastern and South African Telegraph, Ltd., 5 p. c. Mort. Deb. 1900 redeem. ann. drawings, Registered Nos. 1 to 2,343	100	103 —106	103 —106	...	...
198,200*l*	Do. do. do. to bearer, Nos. 2,344 to 5,500	...	103 —106	103 —106	104½	103½
201,600*l*	Do. do. 4 p. c. Mort. Debs. Nos. 1 to 2016, red. 1909	100	99 —101	99 —101	...	...
45,000	Electric Construction, Limited, Nos. 101 to 45,100	10	6 — 6½	5½— 6½	...	...
19,900	*Electricity Supply Co. of Spain, Nos. 101 to 20,000	5	4½— 5	4½— 5	...	...
66,750	Elmore's French Patent Copper Depositing Co., Ltd, Nos. 1 to 66,750	2	... ...	2 — 2¼	...	...
70,000	Elmore's Patent Copper Depositing, Limited., Nos. 1 to 70,000 ...	2	3 — 3½	3 — 3½	3⅛	3¼
67,385	Elmore's Wire Mfg., Ltd., Nos. 1 to 67,385, issued at 1 p.m., all pd.	2	1¼— 1⅝	1 — 1⅝	...	...
20,000	Fowler-Waring Cables, Nos. 301 to 20,300 ... (£4 only paid)	5	2½— 3½	2½— 3½	...	...
180,227	Globe Telegraph and Trust, Limited	10	9 — 9¼	9 — 9¼	9¼	9
180,042	Do. do. 6 p. c. Preference	10	14⅞— 15⅛	15 — 15¼	15 5/16	15
150,000	Great Northern Tel. Company of Copenhagen	10	16¾— 17¼	16¾— 17¼	17 1/16	16 13/16
15,000*l*	Do. do. 5 p. c. Debs. (issue of 1881) ...	100	... ...	... ...	...	...
230,000*l*	Do. do. 5 p. c. Debs. (issue of 1883) ...	100	105—108	105 —108	107⅜	...
9,384*l*	Greenwood and Batley, Ltd., Ordinary, Nos. 4667 to 14,000 ...	10	10½— 11½	10½— 11½	11⅜	10⅞
5,334*l*	Do. 7 p. c. Cumulative Preference, Nos. 2,667 to 8,000	10	11 — 12	11 — 12	...	...
41,800	India-Rubber, Gutta Percha and Telegraph Works, Limited ...	10	19 — 20	18½— 19½	19½	19
200,000*l*	Do. do. 4½ p. c., Deb., 1896	100	103 —105	104 —105	...	...
17,000	Indo-European Telegraph, Limited	25	36 — 38	36 — 38	37½	...
11,334	International Okonite, Ltd., Ordinary Nos. 22,667 to 34,000	10	9¼— 9⅜	9¼— 9⅜	...	...
11,334	Do. do. Preference Nos. 5,667 to 17,000 ...	10	9¼— 9⅜	9¼— 9⅜	...	...
38,348	London Platino-Brazilian Telegraph, Limited	10	6½— 7½	6½— 7½	...	...
100,000*l*	Do. do. do. 6 p. c. Debentures	100	108 —111	108 —111	...	...
43,900	*Metropolitan Electric Supply, Ltd., Nos. 6,101 to 50,000 (£8 paid)	10	7⅞— 8¼	7¾— 8¼	8 1/16	7 13/16
438,984	National Telephone, Limited, Nos. 1. to 438,984	5	4⅜— 4⅝	4⅜— 5	4 3/16	4 1/16
15,000	Do. 6 p. c. Cum., 1st Preference	10	12½— 13	12⅝— 13½	13	...
15,000	Do. 6. p. c. Cum. 2nd Preference (£8 only paid)	10	10¾— 10⅞	10¼— 10⅝	...	...
220,000	Oriental Telephone, Ltd., Nos. 80,001 to 300,000 (11s. only paid)	1	1/16— 1/16	¼— ⅜	...	...
9,000	Reuter's Limited	8	8½— 9	8½— 9	8½	...
209,750	South of England Telephone, Limited, Ordinary Nos. 1 to 2,000, 2,501 to 3,500, 93,251 to 300,000	1	⅛— ⅜	⅛— ⅜	...	...
20,000	Do. 6 p. c. Cum. Pref., Nos. 1 to 20,000 (£3½ only paid)	5	2⅝— 3¼	2⅝— 3¼	...	...
3,381	Submarine Cables Trust	Cert.	115 —120	115 —120	..	...
78,949	Swan United Electric Light, Limited ... ... (£3½ only paid)	5	4⅛— 5	4½— 5	4 9/16	...
37,350	Telegraph Construction and Maintenance, Limited	12	46 — 48	46 — 48	47⅛	46⅜
150,000*l*	Do. do. do. 5 p. c. Bonds, red. 1894	100	102 —105	102 —105	...	...
58,000	United River Plate Telephone, Limited	5	3 — 4	3 — 4	...	...
146,128*l*	Do. do. 5 p. c. Debenture Stock ...	Stock	90 — 95	90 — 95	...	...
3,200*l*	Do. do. 7 p. c. Debs., Nos. 1 to 1,000 ...	100	... ...	... ...	...	...
15,609	West African Telegraph, Limited, Nos. 7,501 to 23,109	10	8 — 9	8 — 9	...	...
290,900*l*	Do. do. do. 5 p. c. Debentures	100	100 —103	100 —103	101⅜	101
30,000	West Coast of America Telegraph, Limited	10	2 — 4	2 — 4	...	...
150,000*l*	Do. do. do. 8 p. c. Debs., repayable 1902 ...	100	94 — 99	94 — 99	...	...
64,174	Western and Brazilian Telegraph, Limited	15	12¼— 12⅜	12 — 12½	...	...
27,873	Do. do. do. 5 p. c. Cum. Preferred	7½	6¾— 7¼	6⅞— 7¼	7	6⅞
27,873	Do. do. do. 5 p. c. Deferred	7½	5¼— 5⅝	5 — 5½	...	...
200,000*l*	Do. do. do. 6 p. c. Debentures "A," 1910 ...	100	103 —106	103 —106	...	...
250,000*l*	Do. 6 p. c. Mort. Debs., series "B" of '80, red. Feb., 1910	100	103 —106	103 —106	...	...
88,321	West India and Panama Telegraph, Limited	10	3⅛— 3⅜	2⅞— 3⅛	3¼	3
34,563	Do. do. do. 6 p. c. 1st Preference ...	10	11¼— 11⅜	11½— 12	11 13/16	11¾
4,669	Do. do. do. 6 p. c. 2nd Preference ...	10	11 — 12	11 — 12	...	...
$1,336,000	Western Union of U.S. Tel., 7 p. c. 1st Mortgage (Building) Bonds	$1,000	120 —125	120 —125	...	...
175,100*l*	Do. do. 6 p. c. Sterling Bonds	100	99 —103	101 —105	...	...
42,853	*Westminster Electric Supply Corporation, Ord., Nos. 101 to 42,953	3	3¾— 4¼	3¾— 4¼	4⅛	3¾

* Subject to Founders' Shares.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Blackpool Electric Tramway Company, Limited, £10 (£6½ paid), 7⅛—7⅜.—City of London Electric Lighting (Pioneer), Shares of £50, £25 paid, 30—32.—Elmore's Austrian Copper Depositing, 20s., 10s. Dis.—House to House Company (£5 paid), 4¾—5¼.—London Electric Supply Corporation, Ordinary (£5 paid), 1¼—1⅜.—Manchester Edison and Swan Company, £9 (£1 paid) 11s.—13s.—St. James's and Pall Mall Electric Light £5, 6¼—6⅜.—Woodhouse & Rawson Ordinary of £5 (£2 10s. paid), 2¼—2⅜.—Preference, fully paid 4¼—4⅜.—Debentures 92½—97½.—Woods Electric Car, £10 paid, ¾—1¼.

BANK RATE OF DISCOUNT.—3 per cent. (29th January, 1891).

THE ELECTRIC LIGHTING OF PARIS, ITS SUCCESS AND COST.

THE voting of the Budget of the City of Paris, at the Municipal Council, led to an interesting discussion as to the conditions of the electric lighting of that city, the gist of which we append below:—The agenda paper gave notice of a discussion on the report (which has been printed and distributed) presented by M. Paul Brousse, on Articles 30 and 31 of chap. 16 of expenses (Improvement of the lighting by gas; Improvement of the lighting by the electric lighting). The proceedings were opened by

M. PAUL BROUSSE (the reporter on the report), who said: Gentlemen,—The Administration places on the Budget for 1891 the two following credits: Chapter 16, Article 30. Improvement of the lighting by gas, 50,000 francs. Article 31. Improvement of the lighting by the electric light, 100,000 francs. These are the figures for 1890. As to the motives and developments, the Administration accompanies these two credits by some explanations. As far as concerns Article 30, it says: "A large number of the Paris streets are yet only provided with a very mediocre lighting, the improvement of which is loudly called for." As far as concerns Article 31, it announces that it intends this credit to provide for the expenses "which will be necessitated by the substitution of lighting by electricity for gas in the different streets, promenades," &c. We will make a short observation *apropos* of Article 30: We perfectly admit the necessity of improving the lighting in the streets where it is mediocre. But we hold that for this alone we should not use the credit of 50,000 francs which we consent to place to Article 30 of the Budget. If gentlemen will refer to the plan which accompanies my report on public lighting they will see that several streets are still lighted by oil. A portion of the credit will therefore be employed in substituting gas for oil lighting. The credit of 100,000 francs which we insert by agreement with the Administration in Article 31 will claim our attention for a longer time. The Rue Auber and the Rue des Halles are lighted by candelabra furnished with incandescent lamps, and a fraction of the Avenue de Clichy, that which touches on the wall of the enceinte, is lighted by means of arc lamps. Now the experiment has been made, it is proper to consider the results. I have been enabled to observe day by day the excellent effects which have resulted for the public safety from the lighting by arc lamps from that part of the Avenue de Clichy which borders the fortifications. But as that portion of the Avenue is situated entirely in the district which I have the honour to represent at the Council, I fear that my opinion might appear to be influenced by the very natural care for the local interests, the defence of which is confided to me. Thus, I resolved to simply ask the opinion of the commissary of police of the district. This opinion has come to me by the hierarchic route, under the form of a letter which the Prefect of Police has addressed to me, and which will be found among the appendices to the report. From this it will be seen that the results are excellent, since from the avowal of the Prefect, naturally disposed to reckon on the vigilance of his agents, this light has driven away suspected individuals who formerly took up their positions in the lower portion of this avenue, and since neither nocturnal assaults nor serious accidents have been reported. The Prefect insists strongly on the necessity of still continuing in the way we have entered upon. The trial of public lighting by means of candelabra supplied with incandescent lamps took place in the Rue Auber and the Rue des Halles. The lighting of the Rue Auber was handed over to a company by an agreement, which comes to an end on March 31st next. That of the Rue des Halles has been supplied from our municipal station In the Rue Auber the working of the service has been very good. The effect which has resulted from it has been a lighting similar to that produced by gas—same intensity, same colour. From a technical point of view, success has been complete. That is what we called for when we prepared our report last week. The lighting of the Rue des Halles has been subjected to the same illuminating and extinguishing exigencies as the old lighting by gas, and here also, as in the Rue Auber—better, perhaps—the working has been excellent. There remains the question of price. From calculations supplied by the Administration, it appears that the electric lighting of the Rue Auber gives rise to an annual expense double that of lighting by gas, and that the electric lighting of the Rue des Halles has led to a double expense for a lighting increased only by three-quarters. From the two trials of the Rue Auber and of the Rue des Halles it must be considered that, in the present position of lighting by incandescence, that lighting is too dear to be used in the public thoroughfares. There must be substituted for it either lighting by gas or lighting by the arc lamp. We propose, therefore, to suspend, from March 31st, the date of the expiry of the agreement, the lighting of the Rue Auber by incandescence. We have more hesitation as regards the lighting of the Rue des Halles. There we have an available electrical energy which is not yet consumed by our subscribers, and which remains without being utilised. It may be used till we receive a new order to light the Rue des Halles. But it seems to us that the Administration will be able to put it to a better use—to the lighting of the square, for example. From trials which we have made, two things have become apparent: the utility of electric lighting by arc lamps, to assure the public safety on the banks of our canals and in those of our streets which touch upon the fortifications, and the high price of the lighting of our streets by incandescent lamps. For these reasons, gentlemen, we ask you to grant the administration the two credits which it asks.

M. LYON-ALEMAND: I want a slight alteration made. It has been proved that lighting by incandescence has not given good results, and is dearer than arc lamps. I ask you, therefore, to decide on lighting the Rue des Halles by arc lamps, and I beg to propose the following resolution: The lighting by incandescence of the Rue des Halles shall be replaced by lighting by arc lamps.

M. PAUL BROUSSE (reporter): I ask for a reference to the committee, for, without wishing to prejudice anything, it may be that the electricity can be better utilised in lighting the Halles Square

M. LYON-ALEMAND's resolution was referred to the Third Commission. Article 30 was fixed at 50,000 francs, and Article 31 at 100,000 francs.

THE MUNICIPAL ELECTRICAL STATION.

The business paper also contained a notice calling for a discussion on the report presented by M. Paul Brousse on behalf of the Budget and Control Committee on Article 27 of Chapter 16 (Expenses of the Municipal Station). That report has been printed and distributed.

M. PAUL BROUSSE: On the Budget project for 1890, the Administration asked us to place a sum of 377,750 francs. We agreed to that, merely remarking that it was a question of an industrial affair at its start, and that from a Budget point of view we had no basis of calculation. We announced that in twelve months it should bring us the balance sheet, and should thus have a basis of operation. This year we have received a very complete report on the working of the municipal station. The sum asked by the Administration for 1891 is 361,350 francs. Last year it was 377,750 francs. There is therefore a saving of 16,400 francs. This increase is only apparent, however. The expenses of the staff to look after the electric lighting (12,400 francs) and other expenses (4,000 francs), which were found in this article in the last Budget, have been taken therefrom and attached, the first to Chapter 3, Article 1 (300 francs), and the second to Chapter 12, Article 2 (306 francs). The Municipal Council has decided that the municipal station shall have autonomous accounts. If then, under pretext that these are staff expenses, there disappears from this Article 26 a sum of 16,400 francs, a cause of error will be created in the Budgets of previous years. You have been able to see in my report the division of the expenses proposed by the Administration, and which amount to 361,350 francs. These expenses must be covered by receipts estimated at 460,500 francs. This product is based on hope "It is admitted" that the station will deliver 60 per cent. of its power to private service. But I do not insist on that here; the reading of the appendices which accompany this report is sufficient to enlighten you. Before concluding these short observations, your reporter protests most energetically against the conditions of labour imposed upon the workmen at our municipal station. The length of the day at the municipal station is eleven hours, from 7 to 7, day and night. Rest, one hour. And a week of night work per month without increase of wages. I must also add that when the men pass from day work to night, they work 24 hours without rest. It will be agreed that these conditions of working are inadmissible, and that we must break with those practices which makes the City of Paris the worst of masters. In conclusion, we propose the following credits to you:—Proposals of the Administration, Article 27, 361,350 francs. Proposals of the committee, Article 37, 361,350 francs. Article 27 *bis* (expenses written down to the staff), 16,400 francs.

M. MARSOULAN: It is certain that some of the men work too long. They have 24 hours' work nearly every day, and receive almost derisive wages. I have, therefore, the honour to propose the following resolution:—The undersigned propose: That the wages paid to *conducteurs* and *piqueurs* of the electricity station, which were 50 francs per month for the *conducteurs* and 60 francs for the *piqueurs*, be raised to 150 francs per month for the *conducteur* and to 125 francs per month for each *piqueur*, which represents a total sum of 525 francs, an increase of 269 francs on the present proposal.—Signed, Lyon-Alemand, Marsoulan, Delhomme.

M. LYON-ALEMAND: Even though the men should accept, or, rather, should prefer an increase in wages, it would be necessary to modify the conditions under which they work, which are truly intolerable. The ventilation is insufficient, and I hope the Administration will profit, in order to improve the service, by the reorganisation which it will be forced to make when the entirety is in working.

M. CHAUVIERE: The most robust workmen in the cellars of the Halles fall ill; some have had to stop work. I therefore ask that the observations of M. Brousse be considered.

The DIRECTOR OF WORKS: Gentlemen, in this question I have acted as referendum. I have called the men together, and have asked them whether they would prefer a rise of wages or the creation of a new staff. In reality, their work is only to look after apparatus——

M. MARSOULAN: Very delicate, however.

The DIRECTOR OF WORKS: Yes; but there is no expenditure of strength. They therefore preferred a rise of wages. The ventilation has, moreover, been improved, and since, the illnesses, which were formerly so frequent, have almost completely disappeared. What is, then, the position of affairs? Does the Council wish to reduce the hours to eight, and to create a new staff? If it does, it will either have to lower the present wages or to considerably increase the credit.

M. PAUL BROUSSE: We must consider the question as a whole, and not in the particular case of the Halles. There, as elsewhere, the City of Paris is the first to violate the conditions of labour voted by the Council. I persist, therefore, in my demand for an inquiry. Still, I do not see any inconvenience in voting the resolution of MM. Lyon-Alemand and Marsoulan.

M. LYON-ALEMAND: I do not absolutely ask for the creation of a third staff. I understand very well that the work being rather an overlooking than an effective work, the men may exceed eight hours' presence. But I insist that, from the time of the reorganisation, the day be reduced from 11 or 12 hours to 9 or 10.

The PRESIDENT: I put to the vote MM. Lyon-Alemand and Marsoulan's amendment, tending to increase by 525 francs the credit to be inscribed on Article 27.

The amendment was adopted. Consequently, Article 27 was fixed at 361,875 francs. Article 27 *bis* was fixed at 16,400 francs, and Article 25 at 360,000 francs. Article 26 was adopted without opposition, and the proceedings terminated.

REVIEW.

First Principles of Electrical Engineering. By C. H. W. BIGGS. London: Biggs & Co.

This is a work professing to deal with electrical engineering. If the preface should by any mischance be taken seriously, it will undoubtedly cause dismay in the heart of many a writer whose efforts have hitherto been accepted as worthy expositions of elementary electrical science, and whom, indeed, the author with elegant directness and empty egotism characterises as "fools." We, however, nervously heave a sigh of relief after the author's intimation that "there is very little in the book that will clash with the views of workers like Crompton, Hughes, Hopkinson, Kapp, &c.;" and further that "there is no attack or disparagement meant in regard to theorists like Sir William Thomson, Clerk Maxwell, Professors Lodge, Rowland, &c." How thankful we are to receive this modest declaration after observing how far the author goes out of his way to vilify writers of all the elementary text books!

This is a book in which there is much cry, but little—dreadfully little—wool. We are told, in effect, that it will not deal with the "thoughtless iteration of Thales," but with the supplying of a "working foundation to students whose hope is to become practical men;" presumably, from the title, electrical engineers. Yet, will it be credited, a large portion of it is taken up with considerations of frictional electricity—the Wimshurst machine, Leyden jar, condensers for telegraph working, tangent galvanometer, Daniell, Grove, and Leclanché batteries, elementary proposition's in graphic statics, &c., all of which will be found treated in a much clearer and much more reliable fashion in many of the well-known elementary text books denounced by the author in such unsparing terms, as "the sooner their contents are forgotten the better." The construction and action of arc and incandescent lamps are, however, left undescribed, and there is not a single decent detailed illustration of a complete practical dynamo, transformer, secondary battery, or volt and ammeter, or any illustration whatever of an electric motor.

The book is *full* of mistakes (far more mistakes than there are pages), not only in regard to printer's errors, bad English, and careless revision of proofs, but also in regard to first principles and well known data. In fact, should a beginner read this book before he has studied any other on this important subject, he will find it difficult to recover from the many erroneous impressions thus first implanted in his mind. Let it, however, be put into the hands of an advanced electrical engineering student, and he will find it far more amusing than any *novel* he ever read, for, on every other page he will have the pleasure of detecting the most outrageous and flagrant errors ever printed since electricity became a practical science, and he will close the book with a feeling of wonder and amusement at the assurance of the author in having issued such a crude, careless production. He will, in fact, agree with the concluding remarks of the author's preface, that should it not realise what is required it "had better be burnt by the common hangman than put into the hands of students."

Just to observe one or two of the many hundred mistakes in the book, we find at page 133 the following statement: "Taking that every pound of coal consumed in the furnace of the boiler should give 10,000,000 heat units, what part of this energy is obtained in the working circuit as given by the formula $C^2 R$?" This must be "Heaven-born" coal! Or, perhaps Mr. Biggs has just returned from the infernal regions, where the everlasting fuel employed by his Satanic majesty never dies out! Any ordinary British engineer is only too glad if he obtains little more than $\frac{1}{1000}$th of the above mentioned calorific value applied to his boilers.

In many places the author confounds between work, energy, and power, *e.g.*, at page 96, he says, "the watt (unit of work?) = volt × ampère (C × E) 746 watts = one horse-power." At page 78 the text is quite unintelligible when compared with the accompanying figure, for the all important letters, N, S, and R, are omitted. Besides which the author is entirely wrong in asserting that the maximum E.M.F. is generated when the armature coils of a dynamo are moving *parallel* to the lines of magnetic force between the poles of the dynamo!

We withhold further remarks, in view of the magnanimity shown by the author of the book in letting Sir William Thomson, Clerk Maxwell, Hopkinson, Crompton, and others off so very cheaply!

THE SPECIFIC GRAVITY OF SULPHURIC ACID OF DIFFERENT DEGREES OF CONCENTRATION.

IN many cases that occur in practical and experimental work, it is highly important to know the specific gravity of an acid at different degrees of concentration.

Kolb's tables have been almost universally trusted when the value of the specific gravity has been required; but in consequence of the discovery of many errors in these tables, it has become desirable that fresh determinations be made.

These have been undertaken for sulphuric acid by G. Lunge and M. Isler (*vide Zeitschrift für angewandte Chemie*, 1890, p. 129).

The table, of which the following is an abstract, was obtained by the method of graphic interpolation; in the original it is given for intervals of 0·005 (1° Twaddell) in the specific gravity:—

Sp. gr. at $\frac{15°}{4°}$ in vacuo.	Percentage of H_2SO_4	Sp. gr. at $\frac{15°}{4°}$ in vacuo.	Percentage of H_2SO_4	Sp. gr. at $\frac{15°}{4°}$ in vacuo.	Percentage of H_2SO_4
1·000	0·09	1·400	50·11	1·800	86·90
1·020	3·03	1·420	52·15	1·820	90·05
1·040	5·96	1·440	54·07	1·824	90·80
1·060	8·77	1·460	55·97	1·826	91·25
1·080	11·60	1·480	57·83	1·828	91·70
1·100	14·35	1·500	59·70	1·830	92·10
1·120	17·01	1·520	61·59	1·832	92·52
1·140	19·61	1·540	63·43	1·834	93·05
1·160	22·19	1·560	65·08	1·836	93·80
1·180	24·76	1·580	66·71	1·838	94·60
1·200	27·32	1·600	68·51	1·840	95·60
1·220	29·84	1·620	70·32	1·8405	95·95
1·240	32·28	1·640	71·99	1·8410	97·00
1·260	34·57	1·660	73·64	1·8415	97·70
1·280	36·87	1·680	75·42	1·8410	98·20
1·300	39·19	1·700	77·17	1·8405	98·70
1·320	41·50	1·720	78·92	1·8400	99·20
1·340	43·74	1·740	80·68	1·8395	99·45
1·360	45·88	1·760	82·44	1·8390	99·70
1·380	48·00	1·780	84·50	1·8385	99·25

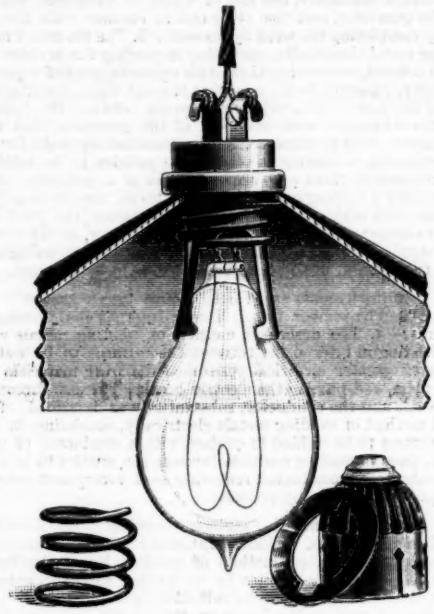
The specific gravity is taken at 15° Centigrade, and compared with that of water at 4° Centigrade. If a curve be plotted from these results, it will be seen that whilst agreeing in many places closely with that of Kolb, it is much smoother, and at the extremes differs somewhat considerably.

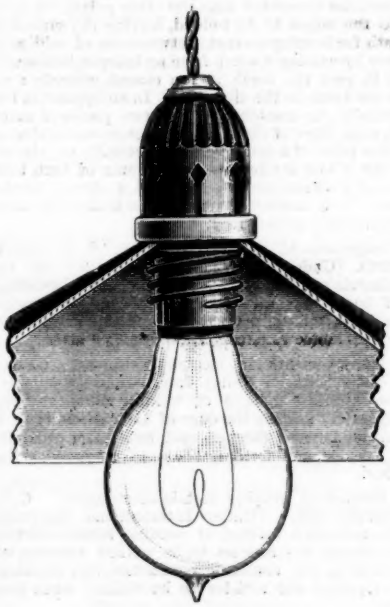
"D. & S." PATENT SUSPENSION PENDANTS.

WE illustrate herewith the top and bottom parts of a suspension fitting now being introduced by Messrs. Dorman and Smith, which presents several novelties.

The ordinary form of cord grip (which is often a grip only in name) is dispensed with, and its place supplied by the arrangement shown, which is both simple and very efficient.

Something new in the way of shade carriers will also be noticed on the lampholders. This is a nut formed of a plain spiral of wire, and while forming a flexible support for the shade, possesses the further advantage that it can very easily





be screwed on and off, and that the shade when made of a brittle substance cannot be broken by the overscrewing of the nut since it keeps flying back whenever overwound.

ELECTRIC LIGHTING OF COLLIERIES.

THE subject of lighting collieries by electricity appears to be attracting more attention at present than has obtained for some time past, and the most recent installations are those put up at Golborne Colliery in Lancashire, Hamstead Colliery, near Birmingham, and Norton Cannock Colliery, near Bloxwich. In the first case, the plant is located in an engine house at an adjoining colliery, and consists of a 25-unit Mordey alternator with its exciter coupled direct to the shaft and driven by belting from a horizontal engine. The dynamo supplies current to 100 lamps of 16 C.P., placed underground, partly in the Golborne Colliery and partly in an adjoining pit; and to lamps of various candle-powers put up in the engine houses, workshops, screens, offices, yards and sidings. In addition to these, about 150 16 C.P. lamps are installed at Golborne Park, where the residence, stables, outhouses, &c., are lighted electrically. The current is conveyed here mainly by overhead conductors from the generating station, and the pressure is reduced in both places by means of hedgehog transformers. This installation has been carried out by Messrs. Mercier, Corlett & Co., of Wigan.

The installation at Hamstead Colliery, Great Bar, has been put up by Messrs. Chamberlain and Hookham, of Birmingham. It is arranged on the series system in conjunction with Bernstein incandescent lamps. The engine and dynamo are arranged in a special building on the surface, and the supply of steam is obtained from the boilers furnishing steam to the colliery engines. From the boilers the steam passes to the engine, which is of the Willans E type, and which actuates, by means of a short belt, a Hookham dynamo giving 10 amperes at an E.M.F. of 500 volts. The dynamo is fitted with an electrical governor for varying the number of lamps in use. From the dynamo the current passes to the switchboard, and from there by means of overhead conductors to two circuits, one for underground lighting and the other for the surface. These two circuits are connected in series at night time so that the engine rooms, decks, &c., above ground may also be lighted, but during the daytime the surface circuit is cut out and the underground lamps only are in use. The bottom decks, office, main roads and stables are electrically illuminated, but no lamps have been placed in the workings. The shaft is 670 yards deep, and the length of the circuit is 3½ miles. There are in all lamps installed equivalent to 50 of 16-C.P. Norton Cannock Colliery is lighted on the same system, but only 30 lamps are in use. This installation has also been carried out by the same firm.

NEW PATENTS—1891.

1,390. "An improved incandescent electric lamp." E. BOEHM. Dated January 26th.

1,396. "Improvements in arc lamps." F. M. NEWTON. Dated January 26th.

1,432. "Improved manufacture of carbon filaments for incandescent electric lamps." C. BOLLE. (Communicated by W. M. B. Keen, United States.) Dated January 27th.

1,527. "Improvements in and connected with apparatus for receiving electrical signals." T. A. GABRETT. Dated January 28th.

1,599. "Improvements in apparatus for stopping any water wheel or other motor used in generating electricity." W. S. ELLIOT. Dated January 29th.

1,639. "Improvements in or connected with distribution of power by alternating currents with the aid of condensers, alternate current motors, fuses, and electrostatic measuring instruments, and improvements in telephone systems." J. SWINBURNE. Dated January 29th.

1,672. "Improvements in laying or running wires for electric lighting." W. T. LORD. Dated January 29th.

1,680. "A new or improved process for the manufacture of wire for transmitting electric currents." A. E. TAVERNIER. Dated January 29th.

1,741. "Improvements in electric welding, and in apparatus therefor." H. HOWARD. Dated January 30th.

1,804. "An improved arrangement of shunt for electric motors." G. F. REDFERN. (Communicated by Wirth & Co., agents for W. Lahmeyer & Co., Germany.) Dated January 31st.

2,334. "Improvements in and relating to electrical communicators for use on public vehicles and the like." J. W. EYRE and C. GRAHAM. Dated February 9th.

2,368. "An antiseptic mouthpiece for telephones, speaking tubes, and like purposes." G. L. ANDERS and J. R. SHEARER. Dated February 10th.

2,417. "A new or improved voltmeter and ammeter." J. MATTHEWS and G. B. CRUICKSHANK. Dated February 10th.

2,418. "Improvements in electric accumulators or storage batteries." J. MATTHEWS and G. B. CRUICKSHANK. Dated February 10th.

2,446. "Improvements in or connected with means or apparatus employed in electrolysis." J. Y. JOHNSON. (Communicated by G. D. Davis, United States.) Dated February 10th.

2,518. "An improved method of depositing copper or other metals by electrolysis, with the object of refining it or them, or of recovering the precious and other metals contained in or alloyed with the metal under treatment." W. GIBBINGS. Dated February 12th.

2,522. "Improvements in attachments or fittings for electric light sliding pendants, electroliers and stand, and other extension lamps." W. R. LANE and J. COTTRELL. Dated February 12th.

2,642. "Improvements in telephone receiving instruments." E. J. P. MERCADIER. Dated February 13th.

2,664. "Improvements in machinery for cutting coal or other minerals, driven by electricity." L. B. ATKINSON and C. W. ATKINSON. Dated February 13th.

2,677. "Improvements in meters for measuring, registering, and recording electrical currents, in part applicable to other measuring and recording instruments." C. A. PARSONS. Dated February 14th.

2,689. "An improved ceiling rose, or connector for electrical circuits, and for the suspension of electrical fittings, and similar purposes." E. W. LANCASTER. Dated February 14th.

2,706. "Making joints and connections in coucentric cables, or mains for conveying electric currents." A. W. HEAVISIDE and R. C. JACKSON. Dated February 14th.

2,714. "Improvements in electric lighting and for other like purposes." R. J. RAY. Dated February 14th.

2,732. "Improvements in flexible supports for electric lamps." W. W. WHITE. Dated February 14th.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1889.

20,486. "An improved system of distributing electricity by means of secondary generators in conjunction with underground conductors." G. E. B. PRITCHETT and H. R. LOW. Dated December 20th. 6d. The inventors enclose the converters, together with the necessary safety appliances, in cases or containers of waterproof material, preferably iron, and provided with a movable cover, the ends of the primary and secondary conductors of the converter being led to a terminal board of suitable insulating material placed within the aforesaid case. These containers are placed at intervals beneath the surface of the ground and in the line of the main primary conductors, which are led through the containers, the ends of the primary conductors of the converters being connected to them on the aforesaid terminal board on which also all joints in and connections from the primary conductors are made; suitable provision is made for rendering watertight the apertures through which the conductors pass. The secondary or distributing conductors are connected to the converter on the terminal board and are led out of the container in a similar manner to the primary conductors. 3 claims.

20,652. "Improvements in incandescence electric lamps." J. W. EDMUNDSON and W. CLARKE. Dated December 23rd. 6d. In order to cheapen the manufacture of incandescence electric lamps, especially of the larger types, in lieu of attaching the carbon rods or filaments to platinum wires by a deposit of carbon, electrotyping or other process as heretofore has been usual, the carbon rod or filament is according to this invention connected directly with a nickel wire or strip that can be attached either directly to platinum or nickel wires which pass through the glass of the lamp or to iron wires or rods that are in turn attached to the platinum or nickel wires which pass through the glass. 5 claims.

20,974. "A system of electric supply or distribution." F. VAN RYSSELBERGHE. Dated December 31st. 8d. Consists in reducing the electric transport to a minimum, by establishing on a uniform electric canalisation a great number of electric generators which produce the electricity on the spot, these electric generators being set in motion by hydraulic motors fed by a canalisation of water at high pressure, established parallel to the electric canalisation. 3 claims.

1890.

7,867. "Improvements in electric motors." H. H. LAKE. (Communicated from abroad by the Giant Electric Motor Company, of America.) Dated May 20th. 8d. Claims:—1. In a multipolar motor the combination of a plurality of groups of equal number of armature magnets arranged in a circle about a common centre, the magnets in each group being located equidistant from each other about said circle and connected permanently together as one magnet, and the several groups being connected to each other in succession; a commutator having as many segments as there are armature magnets and arranged in corresponding groups, the segments in each group being connected together as one, and each group of segments being connected with corresponding points of junction of the several groups of armature magnets, and a field magnet composed of a series of electric helices and having a plurality of both north and south pole ends, the cores and pole ends of said helices being each made up of a series of plates which extend the whole length of the core to the pole end and having its pole end expanded laterally and curved tangentially to a plane at right angles to the axis of the revoluble portion of the motor. 2. In an electric motor an armature having a series of magnet cores arranged with their magnetic axes parallel to the axis of revolution of the revoluble portion of the motor and mounted in supports made of vulcanised fibre or other suitable insulating material, whereby the several cores are insulated from each other, so that if the insulation of the wire of one coil is defective it shall not affect the other coils.

7,988. "Improvements in welding metals electrically." C. L. COFFIN. Dated November 6th. (Under International Convention.) 6d. Claims:—1. The described method of welding metals electrically, consisting in placing the articles to be welded in contact, connecting them with opposite poles of a generator of electricity, passing a heating current through them, simultaneously traversing the joint with an electric conductor, one end of which is connected with one pole of the generator, and the other end in contact with the joint, and finally completing the weld by pressure. 2. The described method of welding metal electrically, consisting in placing the articles to be welded in contact, connecting them with opposite poles of a generator of electricity, passing a heating current through them, simultaneously traversing the joint with a voltaic arc sprung between the joint and a conductor connected with one pole of the generator, and finally completing the weld by pressure. 3. The described method of welding metal electrically, consisting in placing the articles to be welded in contact, connecting them with opposite poles of a generator of electricity, passing a heating current through them, simultaneously traversing the joint with a voltaic arc sprung between the joint and a conductor connected with one pole of the generator, re-enforcing the joint by supplying like metal carried by the traversing conductor and fuzed by the arc, and finally completing the weld by pressure.

7,989. "Improvements in welding metals by electricity." C. L. COFFIN. Dated November 12th. (Under International Convention.) 6d. Claims:—1. The described method of welding metals electrically, consisting in interposing between the surfaces to be welded a conductor of greater electrical resistance than the materials being operated upon, and passing the electric heating current through the said materials and the conductor, substantially as described. 2. The described method of welding metals electrically, consisting in bringing the surfaces to be welded in contact with a conductor of greater resistance, passing heating currents through the articles to be welded and the interposed conductor, removing said interposed conductor and completing the weld by pressure.

7,990. "Improvements in electric welding." C. L. COFFIN. Dated November 19th. (Under International Convention.) 6d. Claims:—1. The described method of welding by electricity, consisting in connecting the articles to be welded with the poles of a generator of electricity in open circuit, closing the circuit by causing an electric spark to pass the break in the circuit, and bringing the articles together to form the weld when sufficiently heated. 2. The described method of welding metals by electricity, consisting in connecting one of the articles with the poles of a generator of electricity, placing a conductor connected with the other pole of the generator in proximity to the edges to be welded, leaving the circuit open, and forming a path for heating currents between one of said articles and said conductor by causing a spark from an independent source of electrical energy to pass the break in the circuit, whereby a voltaic arc is formed in the break in the circuit. 3. In an apparatus for welding metals electrically, the combination with two pieces of metal not in contact with each other of electrical conductors connecting said metal pieces with the poles of a generator of electricity, an electro-magnet included in one of said conductors; a generator of high tension currents connected with said metal pieces, and a circuit breaker in the circuit of said high tension generator controlled by said electro-magnet, substantially as described.

7,991. "Improvement in electric welding." C. L. COFFIN. Dated November 19th. (Under International Convention.) 6d. Relates to a method of electric welding especially applicable to welding together the ends of hoops or similar articles by passing a heating current through the joint, where the natnral tendency of the current is to traverse the article itself instead of the joint. 1 claim.

7,992. "Improvements in electric welding." C. L. COFFIN. Dated November 19th. (Under International Convention.) 6d. Claim:—The described method of welding metals electrically, consisting in separately heating the edge of each article to be welded by passing a heating current through said article in proximity to the edge to be welded and forming the weld by pressing the heated edges together.

7,993. "Method of welding metals electrically." C. L. COFFIN. Dated December 6th. (Under International Convention.) 6d. Claim:—The described method of welding metals electrically, consisting in enclosing the articles to be welded between conductors, electrically heating the enclosing conductors, and forming the weld by pressing together the articles to be welded when brought to a welding heat.

9,125. "Improvements in telephonic apparatus." J. E. KINGSBURY. (A communication from abroad by the Western Electric Company of Chicago.) Dated June 12th. 8d. Relates to that class of multiple switchboard circuits in which metallic telephone lines and single circuit or grounded lines are connected with the same exchange. It applies especially in the use where the operator's apparatus and circuits are so arranged as to avoid the effects of induced currents from other circuits in connection with a uniform test for all the lines. 4 claims.

9,796. "Improvements in and relating to electric circuit controlling apparatus." E. R. GILL, jun. Dated June 24th. 8d. Relates to an escapement device controlled by electro-magnets and provided with electro contacts arranged at different distances apart for operating circuits according to the duration of electric pulsations by simple and accurately responding mechanism of the character indicated, so organised that by a simple permutation of the electrical impulses sent over the line in which a series of such instruments are connected any one of the series may be completely operated to effect any mechanical result capable of accomplishment by electrical devices, or by mechanical means which are brought into action by such device. 10 claims.

CORRESPONDENCE.

Posthumous Scientific Honours.

I have read with much pleasure the contribution and the letter published in your last impression, by Mr. Varley, and I should be most happy if I could give to the celebrated electrician an additional argument for opposing Dr. Silvanus Thompson's hasty conclusions and historical essays on electro-magnets. In his lectures, Dr. Thompson says that Mr. Sturgeon was the inventor of the electro-magnet. I refuted this assumption in an article which is published in *La Lumière Electrique*, and in which I have established, by quoting authentic documents, that the electro-magnet was described by Ampère and Arago, in a lecture that the first of these illustrious physicists delivered before the Academy of Sciences, at an official meeting. The sitting was not public, but all the proceedings were published in a yearly volume edited under the supervision of the perpetual secretaries, then Cuvier and Delanche, if I am not mistaken.

As it was not possible to persist in an assertion opposed by so formidable a document, Dr. Silvanus Thompson retreated somewhat, and said that Sturgeon was the inventor of the *horse-shoe* electro-magnet.

It is possible that I am not in a position to know that Sturgeon was the first electrician to realise a horse-shoe electro-magnet, but I contend that there is hardly any invention in this performance, as the *horse-shoe magnet* was known for a long period previously. The material proof of this assumption can be supplied very easily, as in King's College Museum there is to be found the Siberian natural magnet, which was used by the great Faraday for his induction researches, and this magnet is a *horse-shoe* one. A sketch of this was published, with a notice, a few months ago, by the *Graphic*, where you can find it; you could also publish it again if you think proper. It should save Dr. Silvanus Thompson the trouble of going to King's College to verify my assertion —although, the Finsbury College is not far off—and I should be glad to have his valuable time spared, and to be instrumental in ascertaining the truth, and even of convincing him.

W. de Fonvielle.

Paris, *February 22nd*, 1891.

I find an error has been made in the figures in the last paragraph of the above, which was somehow overlooked when correcting the proof—1882 appears erroneously for 1822, and 1821 for 1831. The sentence in which the mistakes appear should read as follows:—"The revolving star wheel of Barlow and Marsh, described by Barlow in March, 1822, and modified afterwards by Sturgeon into a complete disc, was an electromotor, and Faraday showed this was reversible in 1831; in other words, he showed that energy imparted mechanically to the Barlow-Marsh-Sturgeon motor, produced an electric current similarly as energy imparted electrically produced mechanical motion.

S. Alfred Varley.

February 24th, 1891.

Storms and Telegrams.

What an ingenious mortal Mr. Gilbert is, to be sure! He does warp things as no one else can, and credits me with an attempt to "kick my (notice the my) A-pole out of the earth" when I only pointed out the absurdity of his ideas, as to the use of it. Does he forget that although he claimed greater stability for the A-pole, he recommended the use of it, on straights and slight curves only, and of *single poles, with single stays, on heavy curves*, where any fool knows the strain is greatest. I certainly did not object to the use of A-poles. Unfortunately, they must be used, where there is not room to stay single poles thoroughly, but I still declare that, when old and partly worn, A-poles are sorry substitutes for double-stayed single poles, and experience of such poles, put up years before Mr. Gilbert adopted them, has proved this completely.

Mr. Gilbert has played many parts, but never a grosser one than in claiming the invention of the A-pole. Gentlemen who know even the rudiments of telegraph construction, are well aware that A-poles are a simple development of the strutted pole, and were used all over the country years before Mr. Gilbert *invented* them. What have other telegraph authorities to say on this point? Many could, if they don't think Mr. Gilbert too small game, help to prick the windbag.

Mr. Gilbert refers to my letter in the REVIEW of 15th February, 1889. It was mostly a quotation from a Scotch daily paper commenting on a collapse of the Highland telegraph lines, and specially those on A-poles: "Between Inverness and Colloden the double pole shaped like the letter A, have suffered as much as the single poles." That was great testimony in favour of them, was'nt it?

I have no wish, however, to enlarge in this direction in the meantime, as it is well known throughout the telegraph world that miles of Mr. Gilbert's "New System" of construction, largely got up on the A plan, were swept out of existence by the storm of 8th February, 1889. The nor'easter which tumbled down his two-year-old A-poles, like a lot of ninepins, seems also to have blown him out of the Highlands, and my advice to him now he has touched telegraph, or rather telephone, ground again, would be to "tak' a thocht an' mend," or the next nor'easter may blow him out to the English Channel.

Jno. McDonald.

Mr. Varley's Blunder, and his way out of it.

Two weeks ago I exposed an egregious blunder which occurred in your columns. It was contained in an article on mental capacity, one of those characteristic deliverances of Mr. S. Alfred Varley which have latterly helped to elevate the tone of your paper, while filling out its columns. I am sorry if my exposure of his blunder should have depreciated the market value of any of his contributions to elegant literature. As long as he merely indulged impartially in diatribes against living members of the electrical fraternity all round, there was no need for any of them to notice his lucubrations. But when he went out of his way to charge the British Association Committee of 1862-3-4 with having so low a mental capacity as to apply to the case of variable currents a law which is only true for steady currents, it was really time to point out that the want of mental capacity did not lie with that Committee. Accordingly, I gave a reference to the precise page in the official reprint of the Reports of the Committee on Electrical Standards (p. 102), on which may be found the differential equations for the variable currents, and their solution. The original reports of 1862-3-4 having been in great demand, an official reprint was issued by Sir William Thomson, Dr. J. P. Joule, Prof. J. Clerk Maxwell, and Prof. Fleeming Jenkin. This was published in 1873 under the editorship of Fleeming Jenkin. Eighteen years have elapsed since then. Joule is dead. Maxwell is dead. Jenkin is dead. Sir William Thomson is happily still spared to be our leader. These are the men to whom a Samuel Alfred Varley dares to attribute his own incapacity of intellect. These are the men over whose supposed mistake he exultingly blew his own trumpet! And the mistake is his own.

Detected in this error, and confronted with my simple reference to page 102 of the official reports published in 1873, what does this person do? Apologise? Acknowledge his blunder? Subside into ignominious silence? No: that is not sufficient for one of such superior mental calibre. Instead of doing any of these things he takes the discreditable and incredibly mean course of intimating in no unmistakeable terms that the man who, in 1873, was deputed by his colleagues to edit the reprint of the reports altered or tampered with those reports, so that the blunders of the committees might not appear! The insinuated accusation which Mr. Samuel Alfred Varley never dared to raise during Jenkin's lifetime is wholly false. The paragraphs on page 102 of Jenkin's edition, which refute Mr. Samuel Alfred Varley's silly blunder and prove that the Electrical Standards Committee did not make the mistake which he has imputed to them, are transcribed word for word from the original report of 1863: and will be found (by those who have the mental capacity to read them) on page 169, in the volume of the B. A. reports for the year

1863. It is nothing short of infamous even to hint that Jenkin forged the passages in his edition of the reprint.

As if this were not enough, he goes on to bring against the late Professor Fleeming Jenkin another accusation hardly less astounding, namely, that Jenkin "had reasons" for not supplying Mr. Samuel Alfred Varley with duplicate standards, and, while giving him to understand that other standards would be supplied, "had all along never intended" that they should be so supplied. If Mr. Samuel Alfred Varley and the editors of the ELECTRICAL REVIEW think that it is decent or honourable thus doubly to slander the memory of one whose life and labours were as noble as those of the late Professor Jenkin were, that is their affair. The rest is silence.

Silvanus P. Thompson.

[We do not think it necessary to refer to Professor Thompson's elegant epistle beyond calling attention to the letter below; the two together form as good an illustration of dignity and impudence as does the celebrated representation of these two states of being by Sir Edwin Landseer. Furthermore, we would request the Professor to confine himself to Mr. Varley; the REVIEW can take care of itself.—EDS. ELEC. REV.]

My attention has been called to the following statement which appeared on page 254 of your number of last week :—"I was reluctantly forced to the conclusion that for reasons best known to Fleeming Jenkin, he had all along never intended me to be supplied with a duplicate standard."

The writer, Mr. S. Alfred Varley, clearly did not know Fleeming Jenkin. I did know him, and it is simply impossible that he ever promised to send a duplicate standard intending not to do so. I am perfectly certain that every person who ever knew Fleeming Jenkin must agree with me in this conviction.

William Thomson.

The University, Glasgow,
February 24th, 1891.

Major-General Webber's Paper.

It having been represented to me that my remarks on Major-General Webber's paper on the distribution of electricity, at the Institution of Electrical Engineers, as reported in the technical journals, may give rise to a false impression, I beg to enclose for insertion a letter from the electrician-in-charge, at the Bath Electric Light Works, the correctness of which I have not the slightest reason to doubt. According to this, the defective insulation was not due to the mains, but to faults in the lamp-posts, which alters my view of the suitability of the insulation. The defective circuits were arc-light circuits. The tests of the other circuits were quite satisfactory as shown by the accompanying figures.

Insulation-resistances of Incandescent Circuits.

Circuit No. 1	...	Over 15·89 megohms.
„ „ 2	...	„ 15·88 „
„ „ 3	...	About 5·73 „
„ „ 4	...	„ 3·99 „
„ „ 5	...	„ 0·89 „
„ „ 6	...	„ 0·89 „
„ „ 7	...	„ 0·89 „
„ „ 8	...	„ 0·53 „

Insulation-resistance of Private Arc-light Circuit.

About 0·19 megohm.

The incandescent circuits included the transformers when the above figures were obtained.

George Forbes.

February 24th, 1891.

[COPY.]
Bath Electric Light Works,
Dorchester Street, Bath.
February 21st, 1891.

T. O. Callender, Esq.

Dear Sir,—In reply to your inquiry with reference to the visit of Professor Forbes here, I beg to inform you that all the tests made were on circuits with lamps in series, or transformers connected, and that no tests were taken of the mains by themselves.

The two results to which you specially refer, *viz.*, resistances to earth of 40 and 60 ohms, were on the public arc lines supplying 36 and 45 lamps respectively—and Professor Forbes knew when testing that his figures included lamps and leading-in wires, and did not give, by any means, the actual insulation resistance of the mains.

The low readings in question arose, as a matter of fact, from faults in the lamp-posts. They had just been localised by means of the fault-finding apparatus to which he refers, and on being put right on the following day, the resistances were ·124 and ·146 megohm.

It may be well to point out that Professor Forbes tested all our circuits, eleven in number.

I remain, dear Sir, faithfully yours,
(Signed.) MARTIN C. OLSSON,
Electrician-in-charge.

Cantor Lecture.

Herewith I beg to hand you copies of correspondence between Mr. Gisbert Kapp and myself relative to particulars given by him concerning our Barking installation. As particulars of this lecture appeared in your last number, I should be greatly obliged if you will kindly find space in your columns for the publication of the enclosed in this week's issue.

The General Electric Power and Traction Co., Ltd.
W. G. M. MACKENZIE, *Secretary.*
February 25th, 1891.

[COPY]

February 20th, 1891.

Gisbert Kapp, Esq.
Re Cantor Lecture on Monday, 16th inst.

Dear Sir,—I am requested by the managing director to draw your attention to the enclosed printed matter with reference to data relating to the Barking Road electric installation which is the property of the General Electric Power and Traction Company, Limited. The figures thus given are entirely misleading, and the publication of them is calculated to seriously injure our interests as well as those of the North Metropolitan Tramways Company, and we must request you accordingly to withdraw the Tables 4 and 5, and the statements made by you based thereon at the next Cantor lecture in such a public manner as will be likely to reach all persons before whom the original tables and statements have come.

If the statements have been based upon information obtained from Mr. Frazer, we may call your attention to the fact that he left the company's employ in July last and has since had no opportunity of acquiring any knowledge as to the improvements that have taken place since then, which renders the data published by you still further misleading.

In the event of your failing to comply with our request, we shall, in the interests of our shareholders, be compelled to consult our solicitors on the subject.

Yours faithfully
(Signed) W. G. M. MACKENZIE, *Secretary.*

[COPY.]
31, Parliament Street, S.W., *February 21st*, 1891.

The General Electric Power and Traction Co.,
35, New Broad Street, E.C.

Dear Sir,—In reply to your letter of yesterday, the statements to which you object were based on figures obtained from Mr. Fazer, and were given at the Society of Arts distinctly on his authority and not on mine. After your explanation, which puts a totally new complexion upon the matter, I am, of course, myself desirous to withdraw from my lecture any statement or table, the accuracy of which is questioned, and I shall on Monday withdraw the two tables, 4 and 5, and statements connected with them. At the same time, allow me to point out that in your interest as well as in mine, withdrawal alone would not be so effective as withdrawal combined with the substitution of the correct figures, and I should feel obliged if on Monday you would send me a telegram authorising me to state that when the lectures appear in print the obsolete figures of Mr. Frazer will be replaced by figures corrected up to date and supplied by you.

Yours faithfully,
(Signed) GISBERT KAPP.

Kennedy's New Electrical Distribution Scheme.

Referring to your leading article and Mr. Kennedy's description of his method of utilisation of alternating currents, we think that you might with advantage publish a description of Lieutenant F. J. Patten's system of distribution by alternating currents, an illustration and description of which is given in the New York *Electrical World* of January 25th, 1890. Mr. Kennedy's proposals are on the face of them very interesting, but we think Lieutenant Patten's method has the advantage of simplicity, and certainly accomplishes all the objects proposed by Mr. Kennedy without the additional complication involved in his method.

pro **Mavor and Coulson,**
A. W.

Glasgow, *February 23rd*, 1891.